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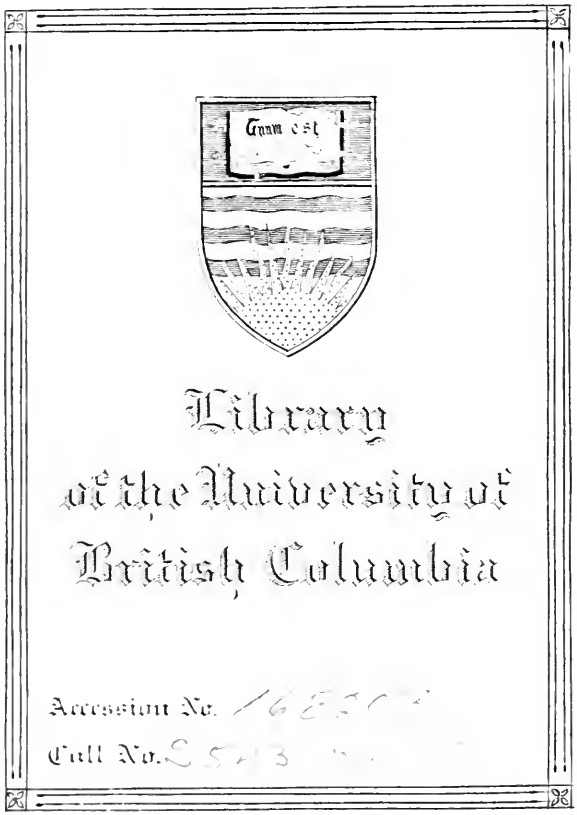

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THE

ROTHAMSTED EXPERIMENTS

AND THEIR

Practical Lessons for Farmers

PART I.—STOCK *PART II.—CROPS*

BY

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PREFACE.

IT would be well nigh impossible to over-estimate the practical importance of the experiments which have now for fifty years been carried on at Rothamsted, in Hertfordshire, by Sir J. B. Lawes, Bart., of Rothamsted Park, and Sir J. H. Gilbert, F.R.S.,—whether the work accomplished by those pioneers of Agricultural Experiment be regarded from the point of view of the interest of Agriculture, or that of the welfare of the whole community.

No other series of investigations on kindred subjects, whether in regard to magnitude, or variety, or continuity, has approached in importance the work thus done at Rothamsted; or, it may safely be said, has had such a beneficial

effect upon British Agriculture, and, indeed, the Agriculture of the world.

The reports of the results of the Rothamsted experiments, however, as they have hitherto reached the public, so abound with technicalities, and contain so much detail, that few except specialists can be expected to realise their meaning and value.

It is the aim of the present small volume to recount, in a readable and practical form, the more obvious and useful lessons which may be learnt from these important investigations; and it is hoped that such a book may prove useful and acceptable to the "general reader," as well as to a wide circle of persons interested, whether directly or indirectly, in Agricultural affairs. The volume divides itself naturally into two Parts—PART I. dealing with STOCK, and PART II. with CROPS.

C. J. R. T.

THE SCHOOL OF AGRICULTURE,
ASHBURTON, DEVON,
10th May 1897.

THE ROTHAMSTED EXPERIMENTS.

PART I.—STOCK.

THE

ROTHAMSTED EXPERIMENTS.

CHAPTER I.

INTRODUCTORY.

Practical value of experiments in agriculture—Experiments conducted by farmers themselves, especially with reference to manuring — Manures most affecting cereals, roots, fodder crops—How to diminish manure without reducing the yield.

It would be impossible in a short work to do justice to the course of experiments which has for over fifty years been conducted at Rothamsted, on the estate, and at the expense of, Sir J. B. Lawes, under the direction of the owner, assisted by Dr (now Sir) J. H. Gilbert. Indeed, a library would scarce be sufficient to chronicle the numerous and varied investigations carried out by these pioneers of agricultural experiment. In agricultural communities throughout the world Rothamsted is a byword, and the names of Lawes and Gilbert are revered as those of men who have devoted lives of disinterested labour to the problems connected with agriculture and the betterment of agricultural practice.

It is astounding, however, in view of the nature and extent of these experiments, how many farmers there are to whom the name Rothamsted is unknown, and to whom the Rothamsted experiments mean the same as other experiments in agriculture, viz., an intellectual pastime for scientific folk, with absolutely no practical value. To such be it known that the smallest cultivator who dusts his tiny patch of arable land with superphosphate, is indebted for that same superphosphate to the investigations made by Sir J. B. Lawes at a period when the movement which characterised agriculture during the latter portion of the century was only beginning to be felt. And the progress which agriculture has made during that period has been due in no small measure to the systematic and practical experiments conducted at Rothamsted. Especially is this so in matters concerning the manuring of land and the feeding of animals.

Probably the fact that the results of the investigations, which from time to time have been contributed to the great agricultural periodicals, bristle with figures and numerical details may account for the somewhat widespread non-acquaintance with the Rothamsted experiments.

Some idea of the extent and nature of these may be gained from the fact that trials have been made on all the commoner farm crops, including wheat, barley, turnips, swedes, mangolds, clover, grass land, &c. All these crops have been grown in succession with and without manure. In the case of the manure plots, simple and mixed manures have been employed

in order to see the effect that the different artificials, as well as farmyard manure, would have on each crop. A great deal of valuable information has been gathered in this way, of which mention will be made later; but it may be incidentally noted that the experimenters have succeeded in growing wheat year after year for over forty years without manure, without ploughing more deeply than in ordinary practice, but keeping the land thoroughly clean. Not only have they succeeded in growing wheat, but the yield has been considerably above the average of the world, and also that of the United States.

Experiments have also been made on the same crops grown in rotation. Also on the feeding of farm animals both for meat and milk.

The land in use for the experiments is about 40 acres, and in all the investigations the greatest possible care is taken that the results shall be of the highest practical value, and every detail accurate. If the practical value of such experiments were really understood, we should have more farmers making trials for themselves, in order to get supplementary information on subjects the general principles of which are brought out by investigations like those at Rothamsted. Take, for instance, the question of manuring. There is probably no branch of agricultural practice in which the farmer is more at the mercy of others than this. His habit in this matter is governed by local tradition or by the manure dealer, and he often knows little of the why and the wherefore of what he does. We do not for a moment wish to throw discredit on local opinion in these circum-

stances. It is often of value, being the result of long experience. His system may be the best or it may not. The chances are that it is susceptible to improvement. For soil, climate, and previous manuring all have an influence on the present necessities of a field; and we take it that the object of any farmer is to obtain the best crops at the lowest possible expenditure, subject to the proviso that he does not permanently impoverish the soil. It does not at all follow that a manure which gives excellent results in one case will give equally good results in another, nor that a manure which generally gives good results is of necessity the most economical in every case. How, then, is the information to be obtained which will enable a farmer to manure on the most economical lines, and at the same time realise the best results? By systematic trial.

From the results of investigations like those at Rothamsted he can obtain information which only requires supplementary local trials to make it valuable. Thus:—

Wheat, barley, and cereals are most affected by nitrate of soda and sulphate of ammonia.

Turnips and swedes by phosphates, such as superphosphates, dissolved bones, basic slag.

Clover, beans, &c., by lime, and by potash manures, as kainit or potash salt, and muriate of potash.

Mangolds, by nitrate of soda and sulphate of ammonia.

Cabbages, by nitrate of soda with superphosphate.

It is not of course intended to convey the idea that no plant food other than that mentioned is required

for the several crops, but it is found that each crop is more affected by one kind of manure than by another, and the above have been found to be the most necessary ingredients in artificial dressings to supplement the usual dunging which the crops may get. As showing how fond one crop may be of one kind of manure which has little or no effect on another, we may instance the fact that in the experiments superphosphate used in conjunction with dung for mangolds produced no increase over the crop raised by dung alone, while the effect of superphosphate on turnips and swedes was exceedingly well marked.

This is information the truth of which holds good for all parts of the country, but there is here no mention of the most suitable amounts of the manure to be applied. These, as already noted, must be determined, and they are not of necessity the same for any two districts. By marking off small plots, or pegging off in cases of roots a certain number of stitches, it would be possible to try several different dressings without much extra trouble and expense, and two or three years would give to the farmer a fund of valuable information as to the nature and quantities of the manures to be applied, and those which would give the best results in the district.

In all cases, however, one of the plots should be tried without manure, so that the inherent fertility of the soil may be determined. Care should be taken that only pure manures are bought, and mixing done by the farmer, or under his supervision. Too great stress cannot be laid on this for many reasons.

Mixed manures undoubtedly often give good re-

sults, but there is very great facility in a complex manure for adulteration, and in spite of the Fertilisers and Feeding Stuffs Act there are still too many cases of adulteration, as may be seen from the reports of the Royal Agricultural Society. Probably if the purchaser would invariably buy from the best firms he would be sure of getting an article which is what it purports to be; but even this is not nearly so satisfactory as buying the manures and making the mixtures on the farm; for in order that a "special" manure may be anything like universally satisfactory it must contain all the pure manures likely to be of use to the plant. The probability is that one or other of these ingredients will be in excess in most soils, and, if so, the purchaser is paying for what is of little use to him, and for which he gets no adequate return. Another matter of importance is that the pure manures — nitre, super, dissolved bones, basic slag, &c.—have a definite market value which is regularly quoted, so that the purchaser knows exactly what he is paying for, and the amount he will require to pay. But in the case of special manures mixed by dealers the price is fixed at their discretion according to the real or supposed qualities of the manure, so that often a much higher price is paid than the article really is worth. Also a manure may appear by analysis to be a rich one and yet be of little value, because it is of such an insoluble nature that it may be years before it becomes available as plant food.

There is another matter in connection with the question of manuring well worthy of consideration,

and which applies more especially to the manuring of roots — turnips, swedes, and mangolds. These require large quantities of manure, and that in such a form that they can readily avail themselves of it. If good supplies are not at hand, a miserable crop of poor, ill-shaped roots is the result. As illustrating this, we may take the results obtained at Rothamsted. For three years in succession turnips were grown *without manure*, with the result that the

First year gave 4 tons 3 cwt.
Third year gave 13 cwt.

With the addition of only 12 tons of farmyard manure each year the produce was raised to

First year, 9 tons.
Third year, 17 tons.

In consequence of this, high manuring has been practised largely in growing these crops—indeed, it is possible that at least in the North farmers are going somewhat into excess.

It was noticed in the Rothamsted trials that a comparatively small dressing would raise a poor crop to a fair one, but it required a very large dressing indeed to raise the crop from a medium to a large one, say from an ordinary yield to a prize crop ; and it was discovered that but a small quantity of the additional dressing was recovered as increased yield in the crop. The question is, Does excessively high manuring pay? Do the few tons extra per acre make up for the extra manure required to produce them?

Certainly a large crop is no more difficult to clean

and work than a smaller one, and if you have a fixed price per ton the balance will probably be in favour of the "bumper" crop; but the value of this is entirely dependent on its feeding qualities, and the difference in weight between an average crop and a heavy one is mostly due to extra water. Bulky overgrown roots are dropsical, average-sized ones being much better feed. Hence it is worth while considering whether it is not better to use somewhat smaller dressings and be satisfied with an ordinary crop.

CHAPTER II.

ENRICHING THE SOIL.

Enriching the soil by the growth of clover and allied plants which abstract manurial matter from the air—The improvement of bad lands thereby at small cost—Rotation of crops—Extension of the length of rotation to suit various soils, climates, and markets—The question of a free hand in the disposal of produce.

SIDE by side with experiments on crops grown year after year on the same plot of land have been conducted elaborate experiments on the same crops grown in rotation. The principles underlying the practice of rotation must be of peculiar interest to farmers, and therefore this portion of the work is of great importance. The practice itself has resulted from years of observation. The oldest idea was to grow wheat—the staple human food—as long as the land would carry it; and when it could no longer be grown, to abandon the soil to nature to restore to a state of fertility. Such a plan has been followed of recent years, and is doubtless now followed on virgin soils.

This method was impracticable when population increased, and the practice of alternating with wheat some crops of an entirely different kind was hit on.

Subsequently, with the introduction of the turnip, the universal practice of rotation may be said to have begun, for the famous "four-course rotation" was the almost immediate outcome. The special quality of the turnip crop does not come in the same place in this rotation as a bare fallow, which usually precedes wheat, but it answers the same purpose, that once, at least, during the rotation the land shall be thoroughly cleaned.

The universal adoption of rotation has had a very considerable effect on agriculture. It has enabled farmers to have practically the whole of their arable land under crop at the same time, not lying idle in bare fallow. By increasing the amount of food produced both for summer and winter, but more especially the latter, it has enabled us to keep more stock, and thus produce more meat and milk and other commodities than would have been possible under the old conditions. It has also so increased the amounts of the various crops grown that we have a higher average produce per acre of all the commoner crops than any other country of the world. It has, indeed, enabled us, in some measure, to stand against the ruinous foreign competition to which we have been subjected; whether it will enable us to do so much longer is another question.

The principles and utility of rotation are easily understood. As already noted, it has been determined that crops differ widely in the quality and quantity of their demands on the soil. Just as animals differ in the food they eat, so do plants. Some are deep-rooted, as mangold and wheat, and obtain their food

from the lower layers of the soil, while others, as white clover and turnips, are shallow-rooted, and obtain their food from nearer the surface. By alternating crops which differ in their mode of feeding and in the demand they make on the soil, we not only make the best use of the soil, but, what is more, save a great deal in manure.

The "four-course" rotation is a typical one, scientifically, but it is by no means universally successful in practice; indeed, in many districts its attempted introduction was followed by complete failure. As, however, it is the type upon which the other rotations are built, and as it is the one adopted at Rothamsted, it may be interesting to analyse it.

The typical cropping is turnips, barley, clover, wheat. The wheat crop leaves as legacy a foul stubble full of twitch; but the turnip crop which follows requires the land free from weeds, and also revels in a fine seed bed. The wheat land is, however, cleared early, and the turnips are sown late, so that there is ample opportunity to clean and work the land. Then, when it is growing, the weeds are regularly kept under, so that the land is thoroughly and completely cleansed. The crop is also heavily manured—indeed, in many cases it is the only crop in rotation which receives manure. Where the crop is fed, practically the whole of the manure used is left for the succeeding crop; but where it is carted there is a considerable drain upon the soil. Under ordinary conditions the plots on which the turnips are fed show an average increase of eight bushels per acre over those from which the turnips are carted.

The accumulated fertility of this crop is made use of by barley—a somewhat shallow-rooted cereal, which requires the food ready to hand, and which is so much dead loss to the field as it is carted away.

After that we have a restorative crop, clover. Clover, which is deep-rooted, collects supplies from the heart of the soil, and not only produces good hay and some pasturage, but leaves behind a rich mass of rootlets, stems, and leaves, which has an excellent binding effect on light soils, and tends to mellow heavy ones; it also contains a large quantity of food for the next crop, part of which has been abstracted from the air.

The land is now in excellent condition for wheat, which was at one time the culminating point of the rotation—the crop for which all the others were merely a preparation. Now, with lower prices, it must take a second place.

Though scientifically good, however, there are many objections to the four-course rotation. It is an expensive one to work, as one-fourth of the whole arable land is under roots, which requires a great deal of labour. This is a consideration where labour is scarce and wages high. Then, too, clover cannot be grown successfully so often as once in four years, as the land is liable to become clover-sick; and turnips grown too frequently are apt to be attacked by finger and toe. This can be remedied to some extent by taking peas, beans, and vetches instead of clover, and mangolds and kohl rabi where possible instead of turnips; but this is only a partial remedy.

A great saving of labour is effected by taking

"seeds" instead of clover, and allowing them to lie two or even three or four years if the land will carry them. Where the "seeds" are allowed to remain two years we have the "five-course" rotation, which is so largely and successfully adopted in the North of England and in Scotland.

Soil, climate, and the markets all help to determine what rotation is most suitable. A rotation suitable for light soil might be impracticable on a heavy one. Then, too, climate has great influence, especially on the length of time "seeds" may remain before it is necessary to plough them up; and of course the demand for produce by regulating the nature of the farming—whether dairying or feeding—will determine the nature of the rotation to a great extent.

During the rotation experiments trials were made to make a comparison between bare fallow and clover, or bean crop, as a preparation for wheat. As the result of a great many years' trials it appears that with the soil in an ordinary state of fertility, and with the rotation receiving an ordinary manuring, the yield of wheat was higher after clover or beans than after fallow—that is, after the growth and removal of the clover or bean crop the land was left in better condition than when it was left without a crop under bare fallow. This result is doubtless due to the fact that from a field on which no crop is growing there is a much greater loss of manurial matter by drainage than when a crop is growing, especially if the season is at all wet; and the greater portion of the loss consists of nitrogen, which constitutes the essential

portion of nitrate of soda and sulphate of ammonia. It is also to be accounted for in some measure by the fact that the clover being deep-rooted, collects food from various depths of the soil, and leaves in the rootlets and foliage (which are ploughed up in the autumn) a plentiful supply of food ready to hand for the succeeding crop. This, however, does not altogether account for the fact that the crop may be removed, and yet the land, without further manuring, produces a larger yield of wheat than if no crop had been taken. Happily we are in a position to explain the matter.

It has been proved within recent years that clover and beans have the power of abstracting manurial matter from the air. All plants take some of their food from the air, but these take up the nitrogen which has just been noted as the chief ingredient in nitrate of soda and sulphate of ammonia, the dearest manures the farmer has to buy. All the members of the pea tribe appear to possess this power of taking manurial matter from the air, and, so far as we are aware, it is confined to this tribe—amongst which may be mentioned lucerne, sainfoin, vetches, peas, clover, beans, &c. It sounds like romance to say that these plants have been enriching the soil at the expense of the air in this way for so long, and yet not until the last few years has anything definite been known of it, but so it is.

Any one who will take up an ordinary clover plant and wash the roots will find here and there on the rootlets small pinkish nodules. These are the factors in the business, the tiny workshops where, in some

mysterious way which has hitherto baffled discovery, the nitrogen of the air is converted for the use of the plant. This special property has not been made use of on a large scale, but it would appear that if rightly used it should prove a great factor in agriculture.

A paper was recently published by Mr Mason, of Eynesham, Oxfordshire, in which he showed how he had made use of this faculty to bring into cultivation a lot of poor land. The land in question, which was on the Oxford clay, was very unproductive, as shown by its yielding only some eight bushels of corn per acre. Instead, however, of manuring heavily with nitrate of soda or sulphate of ammonia, he grew beans and clover, and relied on these plants to abstract from the air what he would otherwise have had to apply at considerable expense in dressings of these manures. What his latest results are we are unable to say, but he spoke very highly of the improvement of the soil even after the first crop of beans, as shown by a tremendous increase in the yield of wheat.

It must, however, be owned that taking the field experiments in all, there is no striking evidence in favour of the four-course, or, indeed, any other fixed rotation. Of their economy there can be no doubt, as by thus alternating crops of different habits, both as regards the depths at which they feed and the food materials they would require, the expense of manuring is reduced and the food materials in the soil are made the best use of; then, too, there is the economising of labour, a great matter in these days of high wages.

The four-course, however, is not enforced so much

now as it used to be; it has given way in many places to more extended rotations by which the expensive root break is reduced; and one result of these experiments is undoubtedly to show that a fixed course of cropping is no absolute necessity.

The whole question hinges on exhaustion. The root crop, for instance, is looked on as a restorative one. But why? Simply because large quantities of manure are applied to it, and the greater proportion of the manure is left for the next crop. If it is carted off it becomes exhausted, and a great deal of manure is required to make it good. The fact is that any crop is exhaustive if it is removed from a field, and it is true that the exhaustion due to any crop may be made good by the application of manure.

That any crop may be grown year after year on the same soil, provided sufficient manure is added, without any danger of exhaustion, has been amply proved in the Rothamsted trials, and this being acknowledged, there is no need for restrictions in cropping at all; indeed, such restrictions are now quite out of place. When the effect of growing the various crops was but imperfectly understood, or the principles of manuring were still obscure, it seemed better for both landlord and tenant that there should be such restrictions. Now, however, all that is required is that the tenant should keep the land free from weeds, and apply a full and adequate compensation in the shape of manure for crops removed. Even the common agreement that two straw crops shall not be taken in succession is unnecessary. Wheat has been grown for over fifty years continuously at Rothamsted, by

applying suitable manures, and the yield shows no signs of diminishing. If, then, wheat, which is considered one of our most exhausting crops, can be grown for fifty years in succession without the land being impoverished, no harm can possibly be done by it, or any other straw crop, being taken twice in succession, provided the land is kept clean.

An incompetent man may require to be watched, and a knave may possibly require to be bound down, but if a competent farmer considers that he may meet the exigencies of climate and soil, of markets and depression, by altering his rotation, then it is in the interest of the landlord and of farming generally that he should have a free hand to do so. The question as to what may be sold off the farm is on the same lines. On many farms the straw may not be sold for fear of impoverishing the farm. If, however, adequate return is made in the shape of manure, there is no exhaustion; and when straw is selling high, it may be a distinct boon to be able to sell it.

The pith of the whole matter is this:—The loss sustained by the removal of a crop or part of a crop can be easily made good by manure, as it is now well understood what manures are best for each crop; that provided those manures are applied and the land is kept clean there is no reason why a good farmer should not be allowed to crop just as he likes; and it is a pity that legitimate enterprise should be hindered by restrictions which are really founded upon a misunderstanding of the laws which govern the growth of farm crops.

CHAPTER III.

THE FEEDING OF ANIMALS.

Feeding animals — Feeding for profit — Early maturity — Proportion of carcase to live-weight — Dependent upon "killing well" — Over-feeding — Manurial value of food-stuffs.

In no branch of agriculture have more rapid strides been made than the feeding of stock. Whether it be feeding for meat or for milk, the older methods have been entirely superseded by more systematic and more satisfactory ones.

Much of this has been due to necessity; much to the improvement in the breeds of farm animals; much to the introduction of food-stuffs; but more to the publishing of results of systematic trial (either in the course of practice or as special experiment) of the relative values of foods of different composition, and the effects of rations containing varying amounts of artificial foods mixed with the common products of the farm—roots, hay, straw. Not that the system is perfect. There is much room for experiment and enterprise, for the margin of profit in feeding, if any, is small, and the nearer to perfection we can approach the less will be the cost of feeding; but much has

been done, and it may safely be assumed that there is still a great deal of information on the subject entirely unknown to the majority of farmers.

There is no "drawing a bow at a venture" in feeding, no mystery about it. Every ounce of increase in a fattening animal, every pound of butter obtained, means so much food consumed by the animal, so much food actually digested and made use of. There may be waste when too much of one kind of food is given, but there is no increase in weight without the necessary food ; no manufacture of butter without the material to make it from. The man who is liberal along proper lines without being wasteful is the one to reap the best results. He soon becomes known in his district as a good feeder, and his stock is looked for by buyers. We have often noticed in the auction marts cattle and sheep which have not been mentioned in the prize-lists fetch much higher prices and sell more readily than the actual prize-winners, simply because they were known to belong to a liberal feeder, and the buyers were confident that they would "kill well."

The improvement in our breeds of animals has had a powerful effect upon our systems of feeding. It may be said that an ill-bred animal rarely pays for feeding either for beef or milk. There are exceptions, of course, but as a rule the well-bred animal is the only one which pays in the long run, and that under almost all conditions, for though the pedigree animal is constantly looked upon as a delicate creature, it is a fact that he can stand roughing it as well as most.

In nothing, however, is the influence of breeding

shown better than in the production of meat. By careful selection—which is the grand principle in breeding—we have obtained cattle, sheep, and pigs with a wonderful aptitude to fatten. Everything that is given to them seems to turn to flesh. The prevailing tendency is to breed animals which will be ripe for the butcher in about twenty months or even less. The great fat stock shows are assisting this by every means in their power by limiting the classes for older stock, and everything is tending towards an increased production of "baby beef."

It was feared at one time that the fattening of stock at such an early age would be detrimental to the quality of the meat, but the outcry against it has long ago ceased, for experience has proved quite the reverse. Even the weights reached by the youngsters are equal to those made by four-year-olds in the past, and there is now a decided tendency in favour of smaller carcases.

The question constantly arises as to whether this system really pays, whether it is not more costly than the older method. The weight of opinion seems to be strongly in its favour. We lately asked a farmer his opinion on the matter, and though he had only recently gone in for "early maturity," he expressed himself strongly in its favour, remarking that if any profit was to be made in feeding at all, there must be steady improvement from the time the animals were born. The appetite and digestive capacity of young animals are much greater than in those of maturer age, and it costs less to get 1 lb. increase in a young beast than in an older one. Sir

J. B. Lawes established this fact some years ago, and subsequent experiments have confirmed it. In actual experiment it was found that the amount of a given food required to produce 1 lb. increase in live-weight was proportionately higher the older the animal, hence that the most profitable use can be made of food when the animal is young.

No one can have an intelligent grasp of the principles of feeding unless he knows something of the nature of food and its duty in the body of the animal. Nor is this, so far as the actually necessary knowledge is concerned, a difficult matter. In milk we have a perfect food, and if we compare its constituents with those mentioned in an analysis of cake, we find that for all practical purposes the cream of the milk corresponds to the oil of the cake, the curd to the albuminoids, the milk-sugar to the carbo-hydrates, and the mineral matter to the ash. Looked at in this light the ingredients of a "cake," or purchased food, appear somewhat less formidable. We do not wonder at the complicated nature of feeding stuffs when we think of the many duties the food has to perform. It is the fuel which keeps up the animal heat and produces the energy of motion as does the coal of a steam-engine. It supplies the material for the increase in weight of a growing and fattening animal, and for the production of milk.

The oil (cream) and the carbo-hydrates (sugars or starches), when burnt up in the body, produce the animal heat and the energy of motion, and what are not used in that way help to form fat and to increase the weight. The albuminoids (curd) are the only

compounds which can form lean flesh—muscle—and are therefore especially required by young growing animals ; they are also largely used in the production of milk. The mineral matter goes to build up the bones, which, as every one knows, are composed large'y of mineral substances.

The functions of the food-stuffs, as indicated, have been discovered by careful experiment, and they are of the highest importance to the feeder, for it is evident from what has been said that whatever be the special object in view of feeding, the food must be arranged accordingly. For instance, a young growing animal will require plenty of albuminoids (curd) to make up its muscles, and mineral matter to build up its bones. These requirements it finds in milk. A fattening animal requires a diet containing more sugar and starch, while a cow in milk requires a plentiful supply of all the ingredients, and, if good milk is required, an extra supply of albuminoids.

With these matters to consider, it appears that feeding is somewhat of a complex business, and more so when we keep in view the wide difference in composition of various food-stuffs. That the foods do so differ should be known to every one, but we have found a somewhat widespread notion that so long as foods are purchased foods they should have the same effect. For instance, we have more than once heard farmers say that they tried Indian meal in place of linseed or some other cake, and gave it up because it did not do so well. It would be difficult to find two foods differing so widely in composition, and they certainly could not be used as efficient substitutes

for one another. Tables giving the composition of food-stuffs are easy of access, but we may mention here that cakes usually possess good percentages of albuminoids and oil, while beans and peas are rich in albuminoids but deficient in oil. Cereals are remarkable for the quantity of starch they contain, with a fair proportion of albuminoids; oats and maize alone having a good percentage of fat or oil. Green fodders and roots contain much water, but are usually deficient in fat.

To know the deficiencies of the food is quite as important as to know what it is rich in, for in arranging rations the great thing is to make up for the deficiencies of one food by judiciously mixing with another, thus at one and the same time making a good ration and giving mixed diet. Maize, for instance, now so largely used, is woefully deficient in ash or mineral matter, especially in lime; and on this account, if used for young animals, the bones do not develop properly unless some other food is given. Young pigs fed at Rothamsted on maize alone, for experimental purposes, were a failure until the expedient was hit on of throwing down phosphates for them to eat. This supplied the bone-forming material necessary. We might go on multiplying instances of the blending of foods, but this is unnecessary. The market value of purchased food-stuffs is, however, constantly fluctuating, and the man who best understands the nature and composition of the foods will be able to buy to the best advantage. On the other hand, the man with limited knowledge will often be compelled to buy in a dear market, and pay a higher price as the result of his ignorance.

It must be borne in mind, however, that whatever be the special object in feeding, it is only the surplus, after the actual maintenance of the animal is provided for, which contributes towards that object. This appears to be often lost sight of. Take, for instance, the question of the keeping up of the animal heat. Whether the animal is fattening, milking, or working, there will be a certain consumption of food for this purpose. If the animal is exposed to cold or inclement weather, the result is that more fuel is required to keep up the heat, and then there is an extra demand on the food. Shelter is equivalent to food, and wherever economical feeding is to be attained, it is indispensable.

Writing on the subject of shelter, Professor Scott, in the Highland Society's *Journal*, 1894, strongly advocates the protection of sheep to a much larger extent than is at present the custom. He points out the number of deaths from exposure, and makes a special mention of the amount of food necessary to maintain the heat of the body under such trying circumstances. In the case of sheep on turnips, he says that they were reckoned at one time as mere manure carts; but now that their mutton is the chief thing, and not the state of the land, he considers that they are worth more care and attention. It is a mere question of money, and the Professor, not content with mere words, gives plenty of figures in support of his contention. As illustrating the effect of cold, let us quote an instance from certain experiments conducted by the Highland and Agricultural Society. A number of cattle were being fed to ascer-

tain the relative values of various feeding stuffs, and in each case the monthly increase was noted. In the third month the increase suddenly dropped to about half what it had been the preceding one, rising again the succeeding month. The reason was that the second month was abnormally cold, the temperature in the byre being often nearly at freezing point. Such extraordinary cold cannot well be guarded against, but the circumstance illustrates the effect of cold on the amount of increase in live-weight from a given quantity of food.

There is in some cases a greater danger from the opposite extreme, in byres where every available outlet is effectually stopped, where the air is so foul that it is impossible to stay in them, and yet in this unbreathable atmosphere animals are kept and expected to do well.

A sufficiency of ventilation is as essential to the health of the animals, and hence to profitable feeding, as are food and shelter.

In spite, however, of properly balanced rations of albuminoid foods and the like, feeding is not a thing of rule, nor are animals machines. If the food is properly proportioned, the animals will best apportion it for themselves. They require careful studying, and whoever has the care of them must take a genuine interest in them if success is to be achieved. The nature of the animal must be taken into account. We have seen cattle being fed up for show, plied with cake and meal till the unaccustomed food caused derangement of the organs, and the animals consequently went off their feed.

The stomachs of cattle and sheep are made for bulky food, and unless a sufficient supply of that is forthcoming the animals cannot be healthy, for nature will always avenge an outrage upon her.

Foods are by no means equally easy of digestion, and numerous experiments have been made to determine the actual percentages of the various food-stuffs which are digested. Without going into these, however, we may note that decorticated cotton-cake, though fairly easy of digestion to older beasts, is poison to calves; and as for undecorticated cotton-cake, it is an open question whether it is not dear at any price, so indigestible is it.

Speaking in general of the subject of feeding, mention must be made of the value of the manure resulting from the consumption of foods. That rich food gives rich manure has been long understood, and it is a regular custom to improve pastures by feeding cake on them; and where turnips are let for feeding, allowance is always made if the owner of the sheep feeds cake or corn with the turnips, on account of the increased richness of the manure.

At Rothamsted a number of systematic experiments were made with a view to the actual value of the manure yielded by one ton of food consumed. The experiments were conducted with every possible care, the whole of the voidings, solid and liquid, being collected and analysed. It is not proposed to give the tables of values here, as they are absolute values, and rarely, if ever, realised in practice. The nearest approach to the full value is when the food is fed on the land, and the least value is obtained when the

manure is exposed in an open yard to every change of the weather, so that the very essence is wasted. The manure obtained from food given to cattle in milk is poorer than that from the same food given to fattening animals, as also is that obtained from young growing animals.

It may be noted that only the mineral matters and the albuminoids in foods have any influence on the value of the manure, the oil and starches and sugars having no manurial value at all, so that if a diet which is somewhat rich in albuminoids is given, there is some satisfaction in knowing that it at least ought to be recovered in the manure.

CHAPTER IV.

THE FEEDING OF CATTLE.

Feeding cattle—Breeds for fattening purposes—Calf-rearing —Profit in fattening — Mixing foods — Use according to digestibility—The cooking and preparation of foods.

THERE is no need, in treating of the fattening of cattle, to dwell long on the subject of the most suitable breeds for this purpose. Lists of the best breeds are constantly before us, and their fame is practically universal. Indeed, the care and attention which has been bestowed on the various breeds of late years is such that it is even now a matter of great difficulty to say which are really the best for fattening purposes. The Shorthorn has long been in the front rank as a beef-producer, but the Aberdeen-Angus is every bit as good; and the shapely Devon, though perhaps it may fatten a trifle more slowly, is little, if any, behind. The Norfolk farmer prefers the Red Poll, and even the Sussex cattle, until lately bred more for draught purposes than anything else, have had such care and attention bestowed on them that they promise to take a foremost place—so that with Herefords, Galloways, &c., there is plenty of choice, and amongst any of the breeds named it is difficult to go wrong.

The Shorthorn, Aberdeen-Angus, Hereford, and Devon perhaps head the list, but local circumstances are one of the best guides as to the most suitable breed. Mention must, however, be made of the place that well-bred cross-breeds, if we may use the term, are taking as beef-producers. The produce of a cross between pure-bred animals usually partakes of the qualities of both parents, besides being a trifle harder in constitution, so that we can understand the position they take at the great shows. The Aberdeen-Angus-Shorthorn cross, and that between the Shorthorn and Galloway, are two of the best known, especially in the North, and many farmers who have large numbers of cattle through their hands prefer them to any other, pure-bred or not. The good qualities of the cross-bred are not, it should be noted, by any means certain of transmission to their offspring, and breeding from them is risky and uncertain.

In connection with fattening, one of the most important things is calf-rearing. If early maturity is aimed at, the animal must improve rapidly from a calf up to the time it is sold; and if it be destined for fattening at a later period, it will be all the better for being carefully reared, and never allowed to get out of condition. In some cases, where calves are required for beef production, and where showing is an object, they may be allowed to suck the dams; but in a general way this is wasteful, at least where there is any dairy produce manufactured on the farm, or the milk be sold. The milking powers of a cow are always impaired by allowing the calf to suck for any

length of time; besides this, hand-feeding the calf allows of the milk being skimmed before it is given, so that the cream may be used for making butter. Using skim milk in preference to whole milk is very widespread now, and by adding linseed jelly the mixture becomes almost as nutritious as new milk. An excellent gruel for the purpose consists of one pint of linseed boiled in six pints of water, and mixed with three times its bulk of milk, a little fine wheat meal or flour being added.

In some places where cheese is regularly made even skim milk is not available, and here calves are generally not reared. The whey resulting from the cheese-making, though generally used for feeding pigs, can equally well be used for rearing calves, provided the substances taken from the milk be made up by adding suitable food. Whey has indeed been used largely in America for this purpose, the deficiency in nutritive matter being made up by dissolving $\frac{1}{4}$ lb. of ground linseed cake in hot whey, and adding to a gallon of whey with a little linseed gruel. At about five or six weeks old $\frac{1}{4}$ lb. of ground oats or barley should be added to each gallon of whey.

Where the whole of the milk can be sold to advantage there is no reason why calves should not be reared on substitutes entirely. With a well-arranged mixture of foods given as a gruel a young animal should thrive almost as well as on a milk diet. In such a mixture linseed meal and linseed cake meal would be largely used, as being amongst the most suitable foods for calves, a small quantity of fine wheat meal being added to correct any relaxing

tendency of the linseed. Success in any case depends upon copying nature as closely as possible, so as to give the animal a good start.

When calves begin to take solid food, all changes in diet should be gradual. They may be allowed to nibble a little sweet meadow hay at first, and gradually become more accustomed to solid food. Care and attention are the keynotes to successful calf-rearing, and the young animals rarely turn out well unless there is a genuine interest taken in them.

We will now proceed to deal with some of the more recent results of Rothamsted feeding experiments—experiments which deal more particularly with animals which were being actually fattened for the butcher.

Some years ago, Sir J. Lawes, in a paper read before a Farmers' Association, discussed the question of fattening and the prospects of profit being realised on it. He gave it as his opinion that unless cattle for fattening purposes could be obtained at a lower price per lb. than they would realise when sold fat, the increase in weight would not pay for the food consumed. To illustrate his argument, he pointed out that in an ordinary diet of mixed hay and straw chaff, with turnips and a moderate supply of cake, there was an intimate relation between the amount of food consumed and the increase in weight of the animal; that (using the latest figures) the latter would consume on an average about 12½ lbs. of dry food per 100 lbs. live weight in a week, and that amount of dry food would produce about 1⅛ lb. of increase in weight. The amount of dry food is taken here, as all foods

contain water, some, as turnips, having nearly 90 per cent., while even the driest contain nearly 10 per cent. If, then, a beast weighed 1,000 lbs. live weight, it would consume about 125 lbs. of dry food per week, and increase in weight $11\frac{1}{4}$ lbs. Now the $11\frac{1}{4}$ lbs. increase would be equivalent to about $7\frac{3}{4}$ carcase increase, as the increase during fattening is largely carcase, and this at 7d. a lb. would be 4s. 6d. There is no suitable combination of the foods mentioned above which would contain 125 lbs. of dry matter and cost less than 4s. 6d., so that the expenditure on the food is actually slightly more than the price realised for the increase in weight.

To illustrate the point, let us apply it to a ration in actual use. A bullock bought in is fed on roots, hay and straw chaff, getting besides 2 or 3 lbs. of cake, increasing gradually up to 10 lbs. Say the weight is 900 lbs. live weight when bought, and that it increases 200 lbs. and is then sold, the weight of course being 1,100 lbs. live weight. The beast would consume (say)

$\frac{3}{4}$ cwt. roots,
10 lbs. to 12 lbs. hay and straw,
Average 6 lbs. cake,
} per day.

Such a ration would give, approximately, the amount of dry matter already noted, and the animal would increase about $11\frac{1}{4}$ lbs. per week, or the 200 lbs. in eighteen weeks. If at the end of that time the animal was sold and realised £18. 6s. 8d., that would be 4d. per lb. live weight. If it had been bought at the same price per lb., this would have been £15, leaving £3. 6s. 8d. to pay for the food and attendance during

the eighteen weeks. The consumed food would be about $4\frac{1}{2}$ tons roots, $13\frac{1}{2}$ cwt. hay and straw, 6 cwt. cake. The cost of this, if we charge the feeding value of roots so low as 5s. a ton, the hay and straw at £2, and the cake, with which some meal would be mixed, at £5 a ton, would be about £3. 19s. 8d., leaving manure against attendance and rent. Thus—

Store bullock, 900 lbs. at 4d., -	£15	0	0
Fat bullock, 1,100 lbs. at 4d., -	18	6	8
	£3	6	8
Food, - - -	3	19	8
Loss, - - -	£0	13	0

It does not matter if the price realised be higher than the £18 given above, for much the same result would be arrived at—viz., that under ordinary circumstances the amount of increase, reckoned at market value, does not pay for the food consumed; that the chance of profit depends almost entirely on the store cattle being bought or reared at a lower price per lb. than they are sold at, which is a precise way of stating that beef must be high and store cattle low. It is this precision, however, which is one of the things most needed in the buying and selling of cattle. At present, in the majority of transactions, neither the buyer nor the seller knows what price per lb. a beast is sold at, each dealing being a speculation. The weigh-bridge makes slow progress, but its more general use both in buying and selling cattle, and during fattening, will do away with a good deal of

speculation, and give a much better idea of the actual value of an animal.

The ration just given is a common and in many respects a typical one, but if viewed in the light of recent experiment, it appears to be capable of improvement. Up to quite recently the generally-received idea was that the best method of fattening consisted in giving, during the concluding stages, an increasing proportion of food stuffs containing a large percentage of albuminoids; hence we have in this ration an average of 6 lbs. of cake, commencing with 2 lbs. and finishing with 10 lbs.

This principle is, however, wrong. In the most trustworthy estimates of the composition of the bodies of the animals of the farm, it is stated that the carcase of a fat ox contains 34 to 35 per cent. of fat, and even the carcase of a calf will contain as much as 16 or 17 per cent. Not only this, but of the increase in weight of an ox as much as 60 per cent. consists of added fat. That is to say, in a fat ox killing 900 lbs. dead weight, there will be as much as 300 lbs. of fat; and of a total increase of 200 lbs. during fattening, 120 lbs. will consist of actual fat. These figures may seem rather high, but this means the total fat, and of course includes that which is found even in the leanest of meat amongst the fibres of the flesh. The process of fattening is properly so-called, and the nature of the food should be such as to produce the increase at the smallest cost. In order that this may be done, we should know the sources of the fat of the animal body, and much light has been thrown on the subject by recent investigation.

At Rothamsted and elsewhere, where experiments have been conducted, the unanimous conclusion is that the fat is manufactured almost entirely from the sugars and starches (carbo-hydrates), or rather that these form the most economical source of fat. Therefore, the best foods for the purpose are those rich in these constituents. The albuminoids — the dearest portion of foods—must take a second place. The fact is that an animal which is matured, or nearly matured, requires only a comparatively small proportion of albuminoids, and what is given in excess is wasted, or at best only finds its way to the manure heap, and to feed to that purpose is doubtful practice. Even an animal which is maturing at the same time as fattening requires less albuminoids than has been supposed. Roots and hay, with 2 or 3 lbs. of cake, would supply a sufficiency of albuminoids for the fattening animal, and the alteration of the food would better have conformed to these views if it had consisted of the addition of say maize meal in increased quantities. Not that there is any special virtue in maize; it is simply a food rich in starch; any other similarly constituted food would do equally well. In short, what is required is simply that the animal shall have a sufficient supply of albuminoids in its foods, but that the alteration in the diet as the fattening proceeds should be in the direction of an increased supply of starchy food supplied, attention being always directed to the digestibility of the food and the natural requirements of the animal.

This may no doubt explain how it is possible to fatten cattle on good roots and oat straw alone.

The amount of digestible albuminoids is very small in these foods, but the sugars and starches are high, and hence the feeder has really been conforming to the rules here laid down. In actual experiment, where the animals were allowed to fix their own consumption of food, it was found that the increase in weight varied regularly with the amount of starches and sugars consumed; that whatever the diet, the same amounts of these foods consumed gave practically the same increase.

A very great matter in economic feeding is undoubtedly the preparation of the food. There has always been considerable controversy over the advantage or disadvantage of cooking or steaming food for cattle. There is no doubt that it is no aid to the digestibility of the food stuff; indeed, there is good evidence to show that in many cases it actually decreases the amount of digestible matter. The success which has attended its employment in certain cases must be set down to its assisting in the foods being thoroughly mixed and thus preventing waste, to its improving the flavour and the aroma of the food, and in some cases allowing of food which was not quite sweet to be used—an advantage which is somewhat doubtful.

In successful feeding for early maturity the food must be chopped or pulped to assist the young animals, whose teeth are not developed, in the assimilation of their food. Even with older animals there is great economy in pulping the roots and chopping the straw. The two can then be mixed and the waste of the straw is thus avoided. Many feeders

allow the mixture of straw chaff and root pulp to stand some hours until the mass undergoes a slight fermentation, which not only makes it more palatable, but softens the straw and makes it easier of mastication. Where corn is being fed, the meal or crushed grain may with advantage be mixed with the roots and straw, as the mixing ensures its complete digestion and prevents waste.

CHAPTER V.

THE FEEDING OF SHEEP.

Feeding sheep — Greater care and attention needed — The best meat-producing breeds—Mixed diets—Feeding hay with roots.

If it is a difficult matter to indicate the best breeds of cattle, it is more difficult to tell the best breeds of sheep. In cattle we do have some kinds specially bred for milk, but in sheep the one object in breeding is a good carcase of mutton, keeping an eye on the fleece ; and as the sheep is the most easily moulded of our domestic animals, we have plenty of choice. Each fancier can bring so many overwhelming proofs of the superiority of the breed he favours, that one is forced to the conclusion that, within limits, the breed matters little if only there be skilful and correct management. To be sure, the hill districts are limited to a few breeds ; but as for the rest, each breed is becoming more cosmopolitan every year. The hardy little Cheviot, which gives such dainty joints of mutton, is finding its way to the South, both for crossing and pure breeding ; and as compensation, we have the Down breeds making their way in the North. The Shropshire is especially widely distributed, and the

Shropshire cross for early lambs has made itself a name all over. Certainly in some districts it scarcely came up to expectations, chiefly because the youngsters could not stand the cold of early spring, but in many localities a little shelter has overcome the difficulty.

For real early lamb the Dorset Horn set the example to the world, for, going with the ram in March and April, the lambs are dropped in sufficient time for them to be fattened before Christmas markets, where, of course, they fetch a fancy price. This industry is at present confined enough, but one wonders whether in some of the more sheltered northern districts, where the cold is far from severe, it could not be successfully introduced. The trouble is great, and much shelter is necessary, but the prices realised are correspondingly high.

Looked at from a fattening point of view, and according to comparative experiments at Rothamsted, the Cotswold gave the largest increase per head per week, and also the greatest increase per 100 lbs. liveweight. There is a growing tendency in favour of this breed in England, but it is much more highly prized in America, especially for crossing purposes. Crossbreds come next, then Hampshires, Leicesters, and lastly, Southdowns.

It was noted that the quality of the mutton was better the lower the fattening capacity, except in the case of the Leicester. This is to some extent what one would expect, for, so far as regards real quality of mutton, nothing can beat the hill breeds. In the London markets Welsh mutton commands the highest

price, but in the north-west there is a predilection for the hardy little Herdwick. This breed can subsist where any other sheep would starve, and is deserving of somewhat more widespread adoption than has hitherto been its fortune. The breed has travelled into Wales, on the hills of which it is so much at home that in some places it promises to oust the native breed.

It will be noticed that the cross-breds took a high place as meat-producers, and in this capacity they are difficult to beat. Half-bred Shropshires, as has already been noted, are known throughout the length and breadth of the land for early fat lambs, and the several varieties of the Leicester are regularly crossed with other breeds to give increased size or greater aptitude to fatten, for which witness the Border Leicester-Cheviot cross or the three-quarter breed, known often as the white-faces, which are esteemed so highly in the North as turnip sheep. They not only mature rapidly, make good weights, and carry a fair fleece, but the mutton partakes of the superiority of the Cheviot mutton, and the sheep can stand a great deal of rough wintry weather without being apparently the worse for it. Note, too, the cross between the Black-faced Scotch and the Wensleydale or Blue-faced Leicester—another hardy cross much used for feeding in exposed districts. Further south the Down crosses—Hampshire and Oxfordshire for preference—are most predominant; and those of the former are reckoned second to none in the country, a grand cross being a Cotswold ram with a Hampshire Down ewe.

According to results of experiments, sheep should be much more economical producers of meat than cattle. In the case of cattle about 11 lbs. of dry food will produce 1 lb. increase in live-weight, while in the case of sheep less than 9 lbs. of dry food will give the same increase. Further, sheep will in proportion to their weight consume much more in food in a given time than cattle; thus, while cattle will eat about 12½ lbs. dry food per 100 lbs. live-weight in a week, sheep will consume 16 lbs. dry food per 100 lbs. live-weight, so that there is a much quicker return in the case of the sheep. Mutton, too, generally fetches slightly more per lb. than beef, and there is the wool into the bargain.

Looked at in this light, the feeding of sheep should be among the most profitable occupations in agriculture. That this is not altogether so in practice is due to a great many causes—some unavoidable, some undoubtedly preventable.

In the South, sheep-feeding is carried on on a system and a regular business; in the North it is reduced almost to its simplest elements. On the hills, indeed, the sheep are practically in a natural state; artificial food is rarely, if ever, given, and only in the severest weather is a little hay and straw allowed them. The flock is not visited except at long intervals, and many a whitened skeleton on the moors tells its own tale of loss to the farmer. On the lowland districts there is somewhat more of an artificial system, but even here we might with advantage take a leaf out of the book of our southern neighbours. The fact is that there is too great a fear among many

of feeding dry and concentrated foods to sheep—grass or roots, with perhaps a little straw, being all they get.

The judicious use of concentrated foods is, however, the truest economy. Look, for instance, at the winter feeding of breeding ewes. This is a matter of the greatest importance, and one upon which the success of the flock depends in the highest degree, for upon the condition of the ewe depends the condition and worth of her offspring. Probably in early autumn the ewes, if not actually flushed with artificial food, have been allowed the run of a choice bit of pasture to improve their condition when going with the ram, but they should on no account be allowed to fall suddenly in condition afterwards, as is sometimes the case when high flushing is practised. The whole of the winter they should have a sufficiency of food without being allowed to put on flesh. When one thinks of the demands which are being made upon the animal at this time, that in the coldest part of the year it has to keep up its own body and support its young, the necessity of a good supply of food becomes apparent. So long as the weather remains open it finds enough on the pastures, but as the winter advances and the grass becomes scarcer, additional food is necessary, or the condition of the ewe falls. If roots are given, they should be supplied only in limited quantities, as in large amounts they are injurious ; but a little sweet hay and some oat straw is essential as soon as frost makes it difficult for them to forage. A little crushed oats may be given, but this is not absolutely necessary. As lambing time approaches, it

becomes more imperative that the animals should suffer no check, and this involves greater care as the ordinary food is getting scarce.

What is wanted is just to keep the ewes in condition, and the results, when the lambs are born, will repay the extra labour and the additional outlay. After the birth of the lambs the ewes should get some succulent food—forage crops or seeds—to encourage the flow of milk; and if it is intended to force on the lambs for early maturity, from ¾ lb. to 1 lb. per day of artificial food, with a little hay, should also be given, which as the lambs grow can be taken from the mothers and given to them. We know that this giving of artificial food is against practice in many places where the great idea is to get the ewes to rear their lambs with nothing but pasture, except when the backwardness of the season makes it imperative that extra food be given. It would surprise many farmers to see the amounts of artificial foods given to the ewes and then to the lambs in districts where lambs are forced for the markets at an early age.

Probably climatic conditions are against anything like an extensive adoption of this forcing system in the North, although the increased weights and additional prices obtained make it seem desirable; but we think there is somewhat of a tendency in these matters to overrate climatic disability. One of the great essentials in the rapid maturing of lambs is the growth of catch crops which shall provide an abundance of green food during spring and summer. With the late harvest this is counted a great difficulty, yet we have seen excellent catch crops of vetches and rye in places

where the generally received opinion is that the growth of catch crops is an impossibility. Without a good succession of forage crops and a plentiful supply of artificial food this forcing to great weights at seven or eight months is impossible. So in the North, winter fattening is the rule, and the root crop the principal factor.

There is considerable difference of opinion as to whether it is better in folding sheep in winter to allow the animals to eat the roots as they grow, or to cut them up and supply them in troughs which are regularly shifted over the break. After Christmas, when the tegs begin to lose their teeth and the swedes are being used, they will require them cut or they cannot thrive, but many advocate the cutting system from the first. There is distinct economy in the amount of roots consumed if they are cut, and the amount of waste by treading is minimised. In a severe winter the roots in the ground are frozen so hard that so long as the frost lasts it is impossible for the animals to feed at all, and food has to be supplied ; then when the thaw does come, many of the roots go rotten and become useless. Of course, one season's experience is not sufficient to condemn a practice, but the increase in the cost of feeding one year may take the gilt off the profit for one or two years to come. The labour involved in the cutting is the great drawback, but it would appear that the saving in roots, taking one year with another, more than compensates for the extra labour.

Whatever be the system employed, there are some practices common to both which will bear discussion.

One of these is the question of feeding concentrated food with the roots. We know successful farmers who feed nothing with the turnips except a little straw, and very little of that sometimes. They can prove easily that it does not pay to give hay, and corn, and cake, as the additional outlay for food is not realised in the increased price obtained for the sheep. Probably when animals are bought and sold by dead weight, calculated, as it can be, with accuracy from the live weight, taking into consideration whether the animal is store or fat, the value of a few lbs. extra increase in the carcase weight will be better appreciated than it now is, but this increase in the fattening power is not the only good result of the feeding of artificial food. The resulting decrease in mortality amongst turnip-fed sheep is one of its greatest recommendations. This mortality is often very high, and there is an old saying that "a good turnip year is a bad one for sheep," indicating that they may have too much turnip. A few deaths in an average-sized flock suffice to reduce profits to a minimum, and anything which will limit the number of deaths without undue expense must be regarded as economical. The use of dry food, too, is conducive to the economy of roots; and, lastly, the value of the manure is largely increased. This is a matter of some importance, as with the decrease in the age of the sheep fed off, we increase the demands on the crop and lower the value of the manure for the next crop.

One of the principles of feeding, whether experimental or otherwise, is that a well-balanced ration is

essential both to the health and the prosperity of the animal ; and, further, that a mixed diet is the best.

A diet of turnips alone, or with even a little straw, can scarcely be said to conform to either of these. In every 100 lbs. of turnips eaten by the animal there is about 90 lbs. of water. Of course, grass contains about 75 per cent. of water, but that gives twice the quantity of dry matter that turnips contain, and, in addition, the amount of water required by an animal is less in winter than in summer. The effect of a breakfast nine-tenths of which is iced water can be better imagined than described, and all the water consumed over and above what is required by the animal is raised to the temperature of the body before it is got rid of, which represents a great expenditure of food to no purpose. One lb. of dry food per head will reduce by nearly 10 lbs. the amount of roots consumed where no dry food is supplied, and would, therefore, lessen considerably the amount of ice-cold water taken into the system. The feeding of dry food minimises the waste, improves the character of the keep, and in every way contributes to greater success.

As to the nature and quantities, say an allowance of $\frac{3}{4}$ lb. to 1 lb. of mixed dry food per head per day with a little sweet hay would be sufficient. Linseed cake has a very good name, but nothing can beat crushed oats ; and as these are grown on the farm, they are probably the best. In the Rothamsted experiments, sheep on turnips gave a higher rate of increase with oats than with either linseed cake or clover chaff, while with only oat-straw chaff the amount of food

consumed to produce a given live weight was half as much again as when oats were used.

A little hay is excellent for fattening sheep. The sheep's digestive organs can make better use of hay than can those of any other animal on the farm, according to experiments on the digestive capacity of our farm stock. Ground peas have been used with good results, and so has wheat ; so that a mixture of all or several of these will be best. It may, however, be noted that, as in the case of cattle, the starchy and sugary foods have the greatest value as fatteners; and that where hay—which is rich in albuminoids—is employed, some such food as maize meal might well form part of the mixture. It is used more largely in the States for feeding sheep than with us.

There is, however, the consideration that maize has a very low manurial value, and when folding sheep we get the nearest possible approximation to the theoretical manurial value of the foods employed.

CHAPTER VI.

THE FEEDING OF PIGS.

Feeding pigs—Great powers of digestion—Results of feeding—Rapidity of increase in weight as compared with cattle and sheep.

THE number of pigs kept in England and Scotland is steadily increasing. The numbers in 1894 are 10 per cent. higher than in the preceding year, which represents a numerical increase of some 44,000 animals in the British Isles; so that the pig occupies a much more prominent place among our live stock than it did at one time. It has become an aristocrat, too, of late years, and has developed a pedigree, so that we have half-a-dozen distinct breeds, each of irreproachable ancestry, and each having many excellent points of recommendation. Perhaps, for a general purpose pig, one cannot do better than select the large Yorkshire White, as, in the language of one who is a great admirer of the breed, "they feed fast and well, come early to maturity, eat all kinds of meal and wash, and are not in the least particular as to choice of food."

For bacon, Tamworths are among the best to be had; and for pork, a cross between the Middle White and the Black Berkshire. We have known several

who regard this cross as second to none, as the animals do well on coarser food than other breeds, feed fast, and make good weights. If there is one thing necessary in keeping pigs for feeding purposes, it is that good animals only be kept. We suppose that the greater portion of the cattle and sheep in England at the present time have a certain amount of breeding about them, even if they have no pedigree, but with pigs it is different. The recognised quality of the breeds has not been so long established, nor the improvements so thoroughly completed and permanently fixed, as in other farm animals, hence the greater necessity for keeping animals of recognised breeding, for here unthrifty, gaunt creatures, which eat heartily but not to profit, and bring a poor price per lb. in the end, are commoner.

To the Irishman the pig is the animal which will eat everything, makes use of otherwise waste material, and turns it into saleable pork. To many farmers in England and Scotland this is the characteristic which appeals most strongly, and it is as a scavenger that the pig takes such a high place in their esteem. One or two are bought in, kitchen wash and waste is given *ad lib.*, a little meal and bran are added, they fatten well, and probably are turned into home-cured bacon and ham.

It is, doubtless, a strong argument in favour of the pig that it can thus make use of otherwise waste material, of tail corn, of small or even diseased potatoes; but if there is one thing shown by the experiments at Rothamsted, it is that the pig will pay for careful feeding. One of the greatest things

in its favour is that it can make use of such a large proportion of its food, and that it has such a wonderful digestive capacity. If we compare it with other farm animals, we find that whereas oxen consume on an average 12½ lbs. per 100 lbs. live-weight, and sheep 16 lbs., the pig consumes 27 lbs. per 100 lbs. live-weight, so that while with oxen every 11 lbs. dry food consumed produces 1 lb. increase, and with sheep 9 lbs. of dry food give the same result, with pigs 1 lb. of increase is yielded by 4¼ lbs. of dry food consumed.

Here, then, we have, according to a well-known authority, "the most economical meat-making machine in the hands of the British farmer." This is due in some measure to the large extent and capacity of the intestines, and also to the fact that the food of the pig does not contain such a large percentage of indigestible fibre, as hay, straw, and grass, which form the staple food of sheep and oxen. That it can digest vegetable fibre was shown in experimental feeding with vetches, in which a very considerable proportion of the fibre was digested.

There is no animal in which the utility of early maturity is so well demonstrated as in the case of the pig, all evidence going to prove how necessary it is. If feeding is to be profitable, then there must be steady progress from birth. Up to a short time ago there was a great tendency to make pigs too fat, so much so as to almost give the idea that the production of lard was the principal object. The system of fattening pursued has got a great deal of the blame, but a more potent factor is the natural tendencies of particular breeds. The fact is, that a breed whose

characteristic it is to lay on a large proportion of fat as compared with lean meat—as, for instance, the Small White—will do so to a great extent irrespective of its food, though if the diet contain a large amount of fattening material it will be worse than if it were of a less fattening nature; and, on the contrary, a breed like the Large White will usually carry a good proportion of lean flesh under any ordinary system of feeding.

This is a matter of common knowledge, and the prevailing tendency is to breed accordingly, and not by selection to manufacture animals which shall become mere balls of lard. The result is aided by selling at smaller weights and at an earlier age than formerly.

It is, therefore, evident that, with due attention to the appetite and health of the animal, the food supplied should be such that the greatest increase can be realised in the shortest time and at the least outlay; and if the breed be right, the result will be satisfactory.

The quality of the meat can be seriously affected by the feeding—a matter which is worthy of note. Corn meal or maize meal has the characteristic of making pork flabby and greasy if fed alone. It is, however, a significant fact that thousands of hogs in the United States are fattened on maize meal alone, and that they make big weights, feed fast, and largely find a market in England when finished.

If hogs are bought as store animals, the object will be to get well-developed animals with good frames, which have been well kept, and which only want filling out with fat to make them fit for the butcher.

But as in this case everything depends upon the price at which they are bought in, we will not touch on this matter, but deal more directly with systematic feeding —from the first a less speculative business.

In rearing pigs for fattening, a great deal depends upon the constitution and qualities of the sow. The question of breed we have already touched on ; but in so essentially a fattening animal as the pig, and whose food is always given to that end, there may be a tendency to forget that in rearing breeding sows the object is not to fatten, but to enable them to develop healthy frames. The constitution of the dam is transmitted in great measure to her offspring; and this being kept in mind, the necessity for careful rearing of the young sow will be apparent. The food should be rich in bone and muscle forming material, and that which is only rich in starch and sugar should not be given to any extent. Skim milk should be given where obtainable, and bran, pea, or bean meal and oats may be given in addition, and young clover and grass are excellent. When we consider the number of pigs at a litter, and that all of these depend for their success upon their dam, it will be seen that too great stress cannot be laid on this. After the breeding sow is fairly well grown, her food should never be such as to cause her to lay on flesh. During the earlier time of pregnancy she will spend most of her time running through the orchards or on the meadows, getting some wash, and as time goes on she will receive sharps in addition. About three weeks before her time she will get better treatment—some bran, brewers' grains, and perhaps a little meal being the additional food.

The drain upon the system of the sow during the period the young are suckling is very great. It has a large litter of young, all of whom are increasing at a rapid rate, and as all this increase comes from the milk of the mother, it represents a demand on the sow which must be met by a liberal supply of food.

Brewers' grains, with sharps and bran, and a little oatmeal, are strongly recommended ; and if skim milk is to be obtained, so much the better. At about three weeks old the pigs are induced to take skim milk with a handful of sharps or bran mixed in it, away from the sow, and softened grain may be thrown to them ; then at seven to ten weeks old they are finally weaned. Many large pig-keepers prefer to keep them the full ten weeks on the sow, as it gives them a much better start. In this case they do better in subsequent feeding, or, if sold as slips immediately, fetch better prices. If the youngsters are to be kept for fattening (which, in view of fluctuations in the price of young pigs, is generally the best plan), it is best to keep them going from the beginning. The young pigs want a good start in the shape of developing bone and muscle, and the food should be arranged accordingly. Skim milk with sharps and bran is excellent, as affording plenty of material for bone and muscle, also a sufficiency of fattening material. If skim milk is not available, oatmeal bran, and maize meal in equal proportions with wash, or cooked, and given as gruel, is recommended. Maize meal should not be given to young pigs without other meals being mixed with it, nor, indeed, to pigs of any age. Professor Stewart, a great American authority on feeding, says that hog cholera (which is

such a frightful scourge in the States) is due in great measure to the indiscriminate use of maize, especially in the feeding of young pigs; and he mentions the case of two pigs fed on this food alone, which at one hundred and thirty days were mere balls of fat, and so weak that they could not stand, and their weight was at least 40 lbs. less than it would have been had they been fed on a better arranged food. He gives skim milk and maize meal as an excellent food in the proportion of 1 quart skim milk to 1 lb. maize. We should prefer a little bran added, as supplying more bone-forming matter. It would then be a better ration than the one in commoner use, of skim milk, bran, and sharps.

At Rothamsted, where pigs have often been fed on maize alone for experimental purposes, it was found that if a little superphosphate of lime was given to the animals they were much better in health, as it doubtless supplied the required mineral matter. In view of this, maize has got a bad name as a feeding stuff for pigs; but there is no doubt that, in conjunction with other meals, especially with bean or pea meal, it is a very valuable feeding material. The amount of meal given should be gradually increased, until at five months the pigs are getting almost all meal, and they should then be ready for sale at about six months. Of a well-assorted meal, about 5 lbs. should give 1 lb. increase in live-weight.

The meal given would, of course, depend upon the market, but barley meal is the kind most suited to the production of meat of excellent quality. Inferior wheat may be ground and used, and for the last week or two

nothing beats oatmeal. It is rather dear, but it finishes a pig off splendidly.

No more food should be given than can be consumed at once; rather feed oftener than allow waste. Whey may be used instead of skim milk where it is more easily obtainable; but it must be remembered that it is not a good food if given alone, especially for growing pigs. Barley and pea meal with a little bran should be given in addition to supply the necessary food. If given in this way, the proportion is about a gallon of whey to 2 lbs. of meal. It will be found that a gallon of whey will equal about 1 lb. of meal in feeding value.

It has been found an excellent plan in feeding pigs on meal to supplement the food with a little chopped clover or similar food, *e.g.*, vetches, the meal being mixed with the clover chop. In an actual experiment, made to see if there were any advantage in this, it was found that the pigs having clover were healthier than those having meal only, that they ate more heartily, and that in five months they increased 40 per cent. more than those fed on meal alone. The pig is almost omnivorous, and hence the admixture of some green food is certain to improve the ration; and, further, the clover chop prevents the meal working up into a dough which would be difficult of digestion.

It is a common custom to run the pigs on grass during the summer, giving skim milk or wash in troughs with a little sharps; turn them on the stubbles in autumn; and immediately afterwards to house them, feed them with steamed potatoes, wash, and sharps, and then give an increasing quantity of

meal, and sell fat at Christmas; or keep them as stores through the winter.

It is contended against this that the active nature of the pig under these conditions causes it to lose condition, which it is difficult to restore. The advocates of this plan say that the animals develop frame and muscle, and improve greatly in value as bacon-producers afterwards. A great drawback over and above loss of condition, however, is that it is a very profitless business fattening pigs in cold weather unless they are kept artificially warm. No animal is more affected by cold than the pig, and in cold weather it eats no more than is required to keep up the animal heat, not increasing in weight, and under any circumstances the increase is much less than in summer. Then, again, if kept as stores during the winter, they are consuming food for which no return is obtained, as there is practically no improvement in their condition, and it takes a great deal more to fatten them afterwards than it would have done the summer before. The weight of evidence would certainly appear to be in favour of feeding them off, wherever possible, in July or August, thus avoiding the expense of keep during the winter.

The susceptibility of pigs to cold, and its effect on fattening, brings forcibly to mind the necessity for care in their housing. If they are to pay, as great care will be necessary as with the housing of other animals on the farm. The sty should face south, should be as free from draughts as possible, but capable of good ventilation, and have a door to the house which may be closed on cold nights.

In speaking of the subject of fat pigs, we may be forgiven if we again touch on a subject which we have already hinted at—the selling and buying by weight, and the more frequent use of the weigh-bridge. Over and over again have competitions been held to show how inaccurate the method of selling by guess is, and in each case the absolute inaccuracy of the method, if, indeed, it may be called a method, has been proved.

Of a fat ox about 60 per cent., of a sheep 58 per cent., of a fat pig (porker) 83 per cent. of the live-weight will be butcher's carcase, so that if the live-weight be ascertained the dead weight can be obtained with certainty. These figures vary slightly, according as an animal is exceptionally fat, when they will be higher, or less fat, when they will be lower.

The weighing, too, of a fattening animal forms the best index to its progress, and if an animal is accustomed to it, does not interfere in any way with its feeding. We are much behind many other countries in this matter, but no system of feeding will really have a chance until we adopt the method of both buying and selling by weight.

CHAPTER VII.

FEEDING FOR MILK.

The typical dairy cow—Variation of amounts of concentrated foods according to the yield of milk—Demands upon the farm for milk and for meat production—Relative profits.

Of ever increasing importance at the present day is the subject of feeding for milk. Dairying in many districts is looked on as the farmer's sheet-anchor, and in many more as the last hope of the British agriculturist. Whether the hopes which are centred in dairy-farming will be realised is not for us to say, but at this time the subject of feeding for milk production should appeal very strongly to every farmer, and the light which has been thrown on it should be of special interest.

"Whatever you do," said an old dairy-farmer, "be careful in selecting your cow." Better advice could not be given, for on that selection depends all the hope of success. A typical dairy cow should be as near wedge-shaped as possible, somewhat light in the fore-end, but large and well-developed behind. If a picture of a Jersey or Ayrshire be taken, and a line drawn along the back to the tail, then one vertically along the tail, a third line drawn along the under-line

from the dewlap to the udder will make a rough triangle with the other two lines. In contrast to this take a typical beef animal, say an Aberdeen-Angus bullock. Here the top-line and under-line are nearly parallel, and an oblong would more nearly enclose the animal. This difference in the two types explains how it is that a very good milker is often a bad fattener.

Perfection of shape, however, is not everything; indeed, we question if it is of necessity the most important point. If you want a horse you look to his legs, and if you want a cow for milk you must look to the udder. True, the development behind is a great thing; your cow must be broad between the hook-bones, and deep; but underneath she must carry an udder "well back and forward, moderately deep, with teats well apart, skin soft and tender, milk veins well shown." There are plenty of other points, but space will not allow of our going fully into the matter; and if the above are properly attended to, the selection will not be far wrong.

Beyond this there is the question of pedigree. This is of special importance to a man who wishes to breed his own heifers for the herd. If he can get cows with good points, and also with an ancestry known to be good milkers, then he can mate them with a bull of good milking strain with certainty as to the result. We know successful dairy-farmers who profess to despise pedigree altogether. "Give me a good cow, and never mind the pedigree." So say we all; but a good cow with a pedigree will be more certain as a breeder of milkers than one which has no pedigree.

We know one farmer who professes not to care a straw for pedigree dairy cattle. He has a capital herd of dairy cows himself, all of which are more or less well bred, if they are not pedigree, and he is certainly not above using the best of bulls; he has, too, a master eye for a good beast; and this, coupled with long years of experience, enables him to tread where others could not safely follow. There is one thing which has somewhat tended to bring pedigree into disrepute, especially in shorthorns, and that is, that until comparatively recently the aim of breeders was to produce animals almost entirely on the model of a beef-producer, the milking properties being left in the background. It was a serious mistake; and though there is an improvement, the bias is still too much in that direction.

The most exhausting time of any animal's life is when she is suckling her young, and this is the time when she should have most generous and well-appointed diet. In the case of the cow, we have not only artificially extended the period during which she gives milk, but we have also much increased the amount of milk which she gives per day. The amount of drain upon the animal will be much more intelligible if we give actual figures showing the amounts of food removed in the milk, and comparing them with the amounts stored up by a fattening animal.

The range of yield is very wide, but suppose a cow to milk forty weeks, and during that period to give 700 gallons (not an unusual quantity for a large cow), that would be an average of 10 quarts a day, and the amounts in lbs. in the milk per week would be—

	Curd (Albuminoids).	Fat.	Sugar.	Mineral Matter.
10 quarts per day, or 17½ gallons per week, -	6.60	6.30	8.32	1.35 lbs.
Or a total for the forty weeks of - - -	264	251	332	54 lbs.

If the cow weighed 1,000 lbs., it would have produced in the year nine-tenths of its live-weight in the solid matter of the milk, and the total production of milk, reckoning the solids as 12½ per cent., would be over 3 tons. These facts bring out forcibly the drain upon the resources of the animal entailed by milk production. There is another matter of interest —the drain upon the farm. This will be best illustrated by comparing the milk with meat production.

Let us suppose a fattening ox to increase 10 lbs. live-weight per week, or, in view of the large yield of milk we have taken, say 15 lbs. per week. If the ox takes twenty weeks to fatten, then in the forty weeks we could fatten two, and they would remove in increased weight—

	Albuminoids.	Fat.	Mineral Matter.
Per week, - -	1.13	9.53	0.22 lbs.
In the forty weeks, -	45.2	381.00	8.8 lbs.

It will be noticed that much less albuminoids and mineral matter are removed in the fattening increase, that the fat is higher, but that there is nothing corresponding to the milk-sugar. As will be shown later, the albuminoids and the mineral matter constitute the most serious drain upon the resources of the farm.

It will thus be seen how essential to the production of milk is a liberal diet, and in consideration of the above it must be noted that whereas the fat of the increase in the fattening is mostly derived from the starches, sugars, and perhaps the oil of the foods, the milk fat is probably largely derived from the albuminoids of the food. Hence the diet of a milch cow should be liberal, and should also be somewhat rich in albuminoids.

The diet given in the Rothamsted herd, which consists of some thirty cows, mostly shorthorns, was—3 lbs. cotton cake, $3\frac{3}{4}$ lbs. bran, $2\frac{3}{4}$ lbs. hay chaff, $5\frac{1}{2}$ lbs. oat straw chaff, $62\frac{3}{4}$ lbs. mangels (when in full milk). The plan, however, is adopted of graduating the amount of cake given according to the yield of milk, the basis being 4 lbs. of cake for every 28 lbs. of milk given. When on grass, cake alone is given, graduated in amount as above; and when in for the winter, in addition to the prescribed amount of cake, bran, hay and straw chaff, and roots (generally mangels) are given.

The graduation of the amount of cake or other artificial food—crushed oats, bean or pea meal, &c.—is now somewhat more widely practised, and has given the best results, for, as is pertinently remarked in the Rothamsted report, "it seemed unreasonable that an animal yielding only 4 quarts per day should receive, beside home foods, as much cake as one yielding several times as much." It may, however, be noted that the diet without the cake is a liberal one, and amply suited to maintain the animals without allowing them to lose condition. In order that the above may

be put in practice, it is essential that a daily record should be kept of the yield of each animal. Such records, if properly carried out, involve very little extra labour, and little outlay. A most convenient one consists of a bucket hung on a spring balance, with a registering dial. The milk as drawn from the cow is poured into the bucket, the weight is immediately registered by the pointer on the dial, and this gives both the weight and measure, as there are about 10 lbs., or more strictly 10½ lbs., in a gallon of milk. The amount is noted on a record sheet opposite the name of the cow, and the owner thus knows the exact yield of each cow, and the total yield of the dairy at any date and for any period.

Apart from any consideration of food, this record is exceedingly useful in other ways. It forms the only reliable method of testing the capabilities of each cow, as in the ordinary way only extraordinary variations are seen, and thus the farmer can see whether it will pay him or not to keep a cow. He will probably have some standard, and if a cow falls below that for her period of milking, he will try to get rid of her ; while if one show specially good milking properties, he will use her for breeding for her herd, with the expectation of stamping her good qualities on her progeny.

If the record shows a sudden drop in the yield of any cow, the owner will know at once that there is something wrong, as the yield of milk is an index to the health of the animal. By weeding out animals that do not come up to a certain standard, and using great care in selection and in breeding, the yield of a dairy may be largely increased, and be made much

more profitable. We have well-authenticated cases of herds averaging upwards of 800 or 900 gallons per head as the result of selection, coupled with judicious feeding.

The method of judging of a cow's capabilities by whether she gives a full pail or not is not sufficiently accurate nowadays, and it may be safely said that if records were kept for a single year in dairies where now there are none, the results would surprise the owners not a little.

That feeding has a great influence on the quantity and quality of the milk there can be no doubt. Here is a complete record of the average yield per head for each month of the year at Rothamsted :—

	Total Daily Yield in Lbs.	Fat per cent.	Solids per cent.	Butter Fat in Lbs.	Total Solids in Lbs.
January, - -	20.3	3.55	12.89	.72	2.62
February, -	22.8	3.53	12.77	.80	2.91
March, - -	24.19	3.50	12.72	.85	3.08
April, - -	26.50	3.43	12.65	.91	3.85
May, - -	31.31	3.34	12.64	1.05	3.96
June, - -	30.81	3.31	12.50	1.02	3.85
July, - -	28.00	3.47	12.60	.97	3.53
August, - -	25.00	3.87	12.95	.97	3.24
September, -	22.94	4.11	13.28	.94	3.05
October, - -	21.00	4.26	13.53	.89	2.84
November, -	19.19	4.36	13.65	.84	2.62
December, -	19.31	4.10	13.39	.79	2.58

In explanation, it may be said that the first column gives the average yield for each cow per day; the second indicates the richness of the milk in fat or

cream ; the third gives the percentage of total solids in the milk ; the fourth column gives the total amount of butter fat in lbs. contained in the amount of milk noted in the first column ; while the fifth column gives the total amount of solids contained therein. It will be noticed that the largest yield of milk was during the summer months while the herd was on pasture, and the lowest yield when it was housed for the winter (that is, during the months of January, February, September, October, November, and December). The average winter yield was 21 lbs., or just over 2 gallons, while the other six months it was 27.6 lbs., or about $2\frac{3}{4}$ gallons ; while in the months of May and June it was over 3 gallons. This proves indisputably that pasture is the best food for producing a large flow of milk. On reference to the second column, it will be seen that the richest milk was given when the cattle were receiving most dry food, and the poorest when they were on pasture. On the other hand, if column 4 be consulted, it will be found that the gross amount of butter-fat yielded per head per day was greatest when on pasture, the larger amount of milk more than making up for the deficiency in quality. The report further adds that the effect of the food is the same whether the cow is newly calved or not.

In the opinion of the experimenters, roots rank next to pasture as milk-producers, being better than silage in this respect. Brewers' grains have long had a great reputation for producing abundance of milk ; and bean meal, pea meal, crushed oats, cotton cake, for improving the quality. Linseed cake is often blamed

for making the butter soft and inferior, and we know many feeders who never give it to their cows when in full milk.

Though it is evident that the quantity and quality of milk is affected by the food, and though it is well known that a good cow will not give a large yield of milk without suitable feeding, there is no direct evidence, so far as the Rothamsted experiments are concerned, to show the extent to which feeding will develop the milking capabilities of a cow. We have, however, before us the record of some American trials which shed light on the subject. The cases are given on the authority of Professor Stewart, and were actual experiences of his own, so that there seems no reason to doubt their authenticity. In the first case he began after a cow had dropped her second calf, and fed her much more highly than formerly, the extra food consisting principally of ground linseed cake and bran with some maize meal. The part he lays greatest stress on, however, was that for the six weeks before she dropped her fourth calf, instead of lessening her food, he kept up the increased feeding to nearly calving time. She had to be milked before calving, as her udder had developed so much, and on testing her milk during the succeeding year the yield was largely increased. The second case—a six-year-old cow that had been moderately kept—was subjected to the same treatment, the extra food being discontinued a week before she calved to prevent fever. Her milking powers were much improved, and on the treatment being continued the next year the yield was found to be nearly double what it had been when the

cow was bought. In both cases the development of the udder was very noticeable.

It is a pity the breed of the cattle is not stated in the account, as we fear that unless the animals were essentially milkers there would be a tendency to lay on fat rather than to increase in milking powers. There is another thing which would have to be considered, and that is the danger there would be to animals in such high condition from milk fever. In spite of this the instances as quoted are very striking.

In the comparison which we have made of the relative amounts of the various substances stored up in fattening increase and those removed in milk, it will be noticed how much higher the amounts of albuminoids and mineral matters are in the second case than in the first. Supposing, then, that the cattle are grazing, the pasture is much more exhausted by the milch cattle than by the fatteners, and consequently needs more careful manuring. The feeding of cake to the cattle on grass somewhat makes up for the albuminoids removed; but the mineral matter, which consists largely of phosphates and potash, must be made up by direct application of phosphatic and potash manures or by thorough dunging.

CHAPTER VIII.

THE FEEDING OF HORSES.

Feeding horses — Necessity for supplying dry concentrated foods — A popular fallacy in feeding — Variation of feeding according as animal is working or idle—Dangers of over-condition.

We have now to consider the feeding of horses viewed in the light of the Rothamsted experiments. Though taken last, the subject is by no means least in importance; indeed, in some respects it is greatest, as it affects not only farmers and tradesmen, but 'bus, tram, and railway companies, as well as those who keep horses for pleasure. The object in view in feeding is entirely different from that aimed at with other farm stock. In the latter case, exertion is avoided as much as possible, and the food is so arranged as to fatten the animal in the most economical manner. In the case of the horse, however, increase in weight is not an object, but the point is so to feed as to keep the animal in the best condition for enduring exertion—in other words, to feed for the output of muscular work. The old idea which governed the feeding of animals was that the harder an animal worked the more were its muscles used up. This was the reason why athletes ate lean meat and

similar food, to make good the muscular waste. The notion has long been exploded in the athletic world, but it has dictated, and does dictate, a great many of the rations used by farmers. They do not feed lean meat, but food equivalent to it is largely fed, and the greater the exertion to which the animal is subjected the more albuminous the diet.

To this end oats and beans form a large proportion of the rations given to farm horses throughout the country. The actual amounts given vary with different districts, higher feeding being probably the rule in the North. A not uncommon ration, however, is 1½ stone of oats per day with hay and straw, some of the oats being commonly substituted by beans, say—

13 lbs. oats,
5 „ beans,
15 „ chopped clover hay with straw,

and when on pasture ½ stone of oats per day, this ration being considered suitable for horses at work. Probably this will be thought high, and in many places only half the amount of beans would be given, and some of the hay would be replaced by mangels or swedes; but for all that it is a typical example of the principle upon which rations are generally arranged — the supplying of material for wasted muscle. This view of the production of work was long ago questioned by Lawes and Gilbert, and since then it has been proved to be entirely wrong. The fact is, the muscles are somewhat like engines— the force required to move them is not derived from their own wear and tear, which is comparatively

small, but by the burning up, not of coal, but of food; and the foods which are best fitted for this, and consequently to enable a horse to do his work most economically, are not those rich in albuminoids, but in non-albuminoids—oil, starch, and sugar.

The practical man will immediately say, "But there must be wear and tear of the muscles when they are used." So there is. The muscles need repair like any other machinery, and for that purpose a certain quantity of albuminoids is necessary; but beyond that it is no more economy to specially feed muscle-forming foods when extra labour is required than it would be to feed iron bars into the furnace of an engine, as the additional exertion can best be met by an increase in the oils or fats and sugars of the food. This simile is not scientifically accurate, on account of the many points of difference between the animal body and an engine, but it illustrates the point in question.

If, then, we suppose a horse at rest receiving a sufficient maintenance diet, the amount of food will require to be increased if we put him to work; but for increase, pure starch or oil would do very well, as has been amply proved by experiment. What will, however, appeal more strongly to the practical farmer is the experience in this matter of tramway and 'bus companies throughout the kingdom. It has of course been the object of these to get the most work out of their animals at the least expense, consistently with their being kept in good condition. In the United States there are hundreds of horses used in this way which get nothing but good hay and maize during

the time they are undergoing hard work. The hay supplies the necessary albuminoids, and the maize the fat and starch. We do not say that this is a feed to be unreservedly recommended—it has too much maize in it for our liking; but it shows how increased labour may be sustained by extra food of a starchy or oily nature, and it must be remembered that maize is the cheapest grain in the market.

Here, however, are a few examples taken from the daily rations of large horse-keeping companies, given in the Rothamsted report in the Highland and Agricultural Society's *Transactions* :—

	North Metropolitan. Lbs.	Liverpool. Lbs.	Glasgow. Lbs.
Beans, - -	2	4	...
Oats, - - -	3	...	6
Maize, - -	13	12	11
Hay, - - -	9	14	$8\frac{1}{2}$
Straw, - - -	3	...	1
Bran, - - -	...	1	...

There are certain companies who use more beans and oats than are here given, but the tendency is all in favour of increasing the amount of maize when the animal is at work.

Here is an example of a ration used by the Paris General Omnibus Company, the amounts given being approximately correct in our system of weights:—

Oats, - - - - - -	8 lbs.
Maize, - - - - - -	$10\frac{3}{4}$ „
Hay, - - - - - -	$8\frac{3}{4}$ „
Straw, - - - - - -	$8\frac{1}{4}$ „

In these cases we have rations derived from combined experiment and practice with hundreds of horses, and arranged with the idea of producing work in the most economical way; and they are, therefore, worthy the consideration of every practical man.

For a horse at rest, or taking but little exercise, a diet of 18 lbs. of hay, or (say) 10 lbs. of hay and 4 lbs. oats, would be amply sufficient; if he were at full work, it would require to be increased by 10 lbs. or more. If hay alone be the chief maintenance, and maize the extra, we have a diet very like that used by the American companies; while if oats and hay are used in conjunction with maize, we have a ration similar to that employed by several English companies.

Circumstances would dictate to the practical man the most suitable food, taking into consideration price, &c.; but the point to be emphasised is that if the resting diet is a sufficient one, as in good pasture grass, there is no gain in giving beans and peas, or other food containing a large proportion of albuminoids, in addition, if the animal is put to work; indeed, the giving of these foods in quantity is not only unnecessary, but is in some cases dangerous. We constantly hear of horses being injured by over-feeding, and it is said that in the Lowlands of Scotland large numbers of horses are killed every year by too liberal rations. We should be inclined to think that the real cause is feeding with food containing too great a proportion of albuminoids, rather than the mere fact of giving too much corn, though this is far from impossible.

The maintenance diet given is sufficient for an average horse, but would not be enough for a large horse, which would require several lbs. more hay; but a horse on pasture will always eat sufficient to support itself, except in heavy work. Once a maintenance diet is fixed, the extra food can be regulated according to work, and risk from over-feeding minimised. There is a caution necessary in connection with these results. If a horse is getting old, or if it is overworked, less maize and more oats or beans may be given with advantage, as overwork to some extent destroys the muscles.

In addition, the results are true only of horses which are matured or nearly so, not of those which are still growing. A horse at light work at two years old, or heavier work at three, and which is still growing, would not be suitably fed by such a diet as many hard-working tram horses get. It must have much less maize and more muscle and bone-forming food—oats, beans, and bran, with good hay—in order to ensure its thorough development. So long as the animal is growing, the great object in feeding must be to ensure its thorough development, and this must be kept in view from the first. Forcing is not desirable, but, on the other hand, steady progress must be made, and there should be no stinting of food. Linseed cake, oats, beans, and good hay can all be used to supplement the pasture when the foal has been weaned, and cut swedes may be given in winter. The care and attention bestowed on the feeding and rearing will be amply repaid when the animal is sold or comes to be used on the farm.

As we have already quoted the companies who employ large numbers of horses with regard to the most suitable rations for work-horses, we may again make use of their experience in reference to the preparation of foods. They have found it economical to feed cut fodder and ground or bruised grain. With uncut hay and straw more was required, and with whole grain there was considerable loss by reason of the food passing undigested through the system. In actual experiment it was shown that 16 lbs. grain (ground), $7\frac{1}{2}$ lbs. cut hay, and $2\frac{1}{2}$ lbs. cut straw, was equal to 19 lbs. of unground grain and 13 lbs. uncut hay, and the horses did equally well on the diet. Though this system is adopted by many farmers, there are several districts where long hay is still fed from overhead racks, and unground grain given; but if the experience of these large horse-keepers is to go for anything, the former method should be used wherever a number of horses is kept, if only on the score of economy. The ground grain is mixed with the cut fodder, slightly damped, and the mixture is fed in a manger. By this arrangement not only is the overhead rack done away with, but the mixing of the ground grain with the chop ensures its thorough mastication, and helps in its digestion. Cooking is not to be recommended in the general preparation of food for horses. Potatoes are steamed before use, and boiled barley is a very good food for horses out of condition through bad teeth; but cooked food, as a rule, has a bad effect. A horse should never be watered immediately after being fed. When a horse drinks, the water does not remain in the stomach, but

passes immediately into the bowels. If, then, when a horse has eaten freely, and the stomach is full of food, it is allowed to drink, the water washes some of the food out of the stomach before it has been properly digested, fermentation sets in, and derangement of the bowels, and even death, may supervene.

A highly-fed animal often gives trouble when allowed to rest at the end of the week after having had a full week's work. The legs swell and become tender and stiff, and there is evident inflammation. On account of its generally appearing after the rest at the end of the week it is known as "Monday-morning evil." The best way to avoid this is to limit the food given after work has ceased, and to give on Saturday night a bran mash with a little saltpetre in it. This has a relaxing effect on the bowels and kidneys, and prevents the disease where there is liability. Many farmers give a bran mash regularly on Saturday night, even where there has been no sign of the complaint, and find it a capital thing for keeping the animals in good health.

There should usually be a little rock salt within reach of the horses, as they like to lick it, and in small quantities it seems to have a very beneficial effect.

PART II.—CROPS.

CHAPTER I.

SWEDES AND TURNIPS.

Dependence of these crops upon heavy dressings of readily available manures—Degeneration of quality and quantity if this is not complied with—Effectiveness of phosphates—Nitrogenous manures not so essential—Typical dressings with or without farmyard manure—Effect of manure in promoting or stopping "finger-and-toe."

THOUGH the experiments carried out at Rothamsted have been of such varied nature, the chief work has been that in connection with the growth and manuring of various crops. Long and laborious have been these experiments, and their magnitude, coupled with the ability and experience of the experimenters, makes them invaluable to all engaged in agriculture. In this little work it is not our purpose to adhere rigidly to the results obtained at Rothamsted, but taking these as a basis, to glean from the experiments information of value which may help to throw light on the subjects under review.

Probably upon no crop has there been such complete and exhaustive investigation as upon roots, especially upon swedes and turnips. This is not to be wondered at when we consider that on many small farms the outlay on the root crop is the one great

expense of the year, and any saving in this outlay would be very welcome. Under suitable conditions, this is a crop which will give enormous yields, and not infrequently it appears as though the whole energy of the farm were concentrated on this object; and in most cases in the north and west the farmer gauges the capacity of his farm for winter stock by the amount of swedes and turnips they will have at their disposal.

In this connection there is one point which has been brought out strongly in the Rothamsted trials which is worthy of note, namely, that the crop is incapable of gathering any of its manurial matter from the air. Time was when it was widely stated that the luxuriant expanse of leaf had the capacity of drawing upon the air for nitrate and other similar manurial matter, and this was a chief reason for speaking of the crop as being restorative. It has, however, no claim to being called restorative; on the contrary, it is entirely dependent upon large supplies of manurial matter ready to hand and in a soluble form.

Years of cultivation have developed in it the habit of shallow rooting, and have robbed it of its power of searching through the soil for its food, as does wheat, for instance. It is to the advantage of the cultivator to preserve this habit. Indeed the whole success of turnip culture depends upon this. Look, for instance, at the effect of attempting to grow turnips or swedes without manure. It has been tried at Rothamsted, and in the second year of the attempt the plants had completely changed their character. Instead of a

full rounded bulb, a long carrot-like tap-root was developed, capable of penetrating the soil and searching for food, but utterly useless for the purpose for which the crop is grown ; and as for quantity, only 12 cwt. per acre were obtained the third year, and the attempt was abandoned. The fact is, that the modern turnip is essentially an artificial production, and only retains its characteristics by careful cultivation. We have seen roots altered in this way on poor land, and the appearance has been set down to "finger-and-toe" when there was no sign of the disease. The roots certainly were deformed and diminutive in size, but this was due, not to "finger-and-toe," but to degeneration of the crop owing to poverty of soil and want of readily available manure. Speaking of readily available food material, it is a fact that is often lost sight of, that only such material as is easily soluble is at once of use to the plant—that insoluble matters must first decay in the soil before they can be made use of.

Swedes and turnips, then, respond immediately to heavy dressings of soluble manures, and crops of upwards of 40 tons per acre can be obtained under suitable conditions of manuring and season. We do not say that such crops are necessary ; indeed, we consider that medium ones are truer economy (a point to which we shall allude later), but we contrast this yield with that obtained at Rothamsted without manure by way of illustration. The predominant ingredient in all artificial dressings for root crops must be phosphates in some form or other, and the demand for this kind of manure is characteristic of all plants

belonging to the same class. Superphosphate alone in one case trebled, and in another doubled the yield obtained without this manure. The addition of potash salts produced no material increase, and though nitrate in addition gave somewhat better results, its effect was not nearly so marked as that of super. These facts have been amply borne out by trials made in other places.

The Highland and Agricultural Society, in their experiments on turnip growing, which trials are carried out by practical men on their own farms, found that 2 cwt. per acre of nitrate of soda with phosphate gave no increase over that yielded by 1 cwt. of nitrate with phosphate. Taking the average of twenty-five experiments, the actual figures were :—

	Tons.	Cwt.
Mixed super and slag, 1 cwt. nitrate,	23	3
Mixed super and slag, 2 cwt. nitrate,	23	19

These had also a dressing of dung. It is noticeable, however, that even where dung was not used, the extra nitrate gave no adequate return. Taking the average of fifteen experiments, the figures were :—

	Tons.	Cwt.
Super and slag, 1 cwt. nitrate, -	20	6
Super and slag, 2 cwt. nitrate, -	20	7

It may be considered that generally $\frac{3}{4}$ cwt. of nitrate sown in two dressings is sufficient. The application of a greater weight results in a tendency to run to leaf and an appearance of great luxuriance; the bulbs, however, are not benefited and appear to mature later.

These facts are of great importance to those farmers who wish to use their own manures, a course which we strongly advocate, both for economical and other obvious reasons. To many, the effects of these manures are well known; but there are, among small farmers, others by whom these general principles are not understood. For their guidance it may be well to again remark that the best manure for one district is not of necessity the most successful in another, and that careful experiment on the lines indicated above gives the most reliable information. Nevertheless, where a dressing of, say, 14 loads of farmyard manure is applied per acre, about 4 to 5 cwt. of super, with ¾ to 1 cwt. of nitrate of soda, will generally give good results. One cwt. of bone meal, or dissolved bone, may be substituted for a like quantity of super; but, judged by results, dissolved bone is scarcely worth its present price as a turnip manure. Some recommend a little kainit to supplement the above, but where good dung is used there is little need for potash in the artificials. Though not so heavy as some dressings which are in use, we consider that greater amounts are not true economy, and that the extra weight of manure is not recovered in increased feeding capacity of the crop, as the heavy bulky roots are correspondingly watery.

There has been considerable controversy as to whether root crops can be successfully grown without farmyard manure. So regular is the custom of consecrating the bulk of the "muck" to the turnip break, that in many places it would be rank heresy to suggest the possibility of the crop succeeding without it; and

yet good crops are successfully grown without an atom of farmyard manure. At Rothamsted the plots manured with dung gave much better results in the third year than the ones manured with mixed artificials; but the continuous growth of an exhausting crop like swedes and turnips on the same land, with artificials alone, results in almost complete removal of the organic matter of the soil, and to this the superiority of dung over artificials, when the crop is grown on the same land year after year, is doubtless due. Such an exhaustion would, however, never take place when roots are grown in the ordinary rotation, the seeds or clover always leaving a sufficient residue in the soil. Hence splendid crops can be raised with artificials alone, when the roots are grown in ordinary rotation. The great advantage of such a plan is that the farmyard manure is available for seed and pasture, for which too often there is little enough to spare.

While not advocating the general adoption of this system, we cannot but think that the amount of dung used for swedes and turnips might be profitably diminished. Trials made by the Highland and Agricultural Society brought out this fact prominently, and we consider that if about half the usual amount of dung was applied to the turnip break, and the balance spread on the young seeds in autumn before the frost comes, and harrowed with a light chain harrow, the results would be much better than expecting the manuring given to the roots to last practically the whole rotation. If farmyard manure is not applied at all, the amount of artificials should be slightly altered and increased. The phosphate may

still be given, mainly as super, which, in spite of opinions to the contrary, has little tendency to be washed out except in very light soils. The amount of nitrate is usually recommended to be increased, but this is questionable practice. A better plan is to give, in addition to super and nitrate, dissolved bone and bone meal, the nitrogen of which, being more slowly soluble, will come on for the plant, when the action of the nitrate is over, beside which they will leave a good residue for succeeding crops.

Such a dressing would be :—

Super, - - - -	5 to 6 cwt.
Bone meal, - - -	1 „ 2 „
Dissolved bone, - - -	1 „ 1½ „
Kainit, - - - -	2 cwt.
Nitrate, - - - -	1 „

In giving dressings suitable for these crops we have made no mention of slag as a turnip manure, for the reason that we wished to call special attention to its value. It has been considerably decried, and we have come across farmers who shake their heads dubiously at its mention in this capacity. As a substitute for super, indeed, it is not altogether successful, and its use is not to be recommended ; but if half the super is replaced by a like quantity of slag, the mixture gives much better results than either the super or the slag alone.

In dealing with this crop we cannot dismiss it without referring to the disease "finger-and-toe," with special reference to the real or supposed influence of manuring on it. Unfortunately, its ravages appear to

be very much on the increase, and every year there is a bitter outcry and an eager demand for a specific. When diseased "bulbs" are used on the farm or thrown on the manure heap, the dung becomes a favourable medium for the perpetuation of the disease and its subsequent distribution ; indeed, it becomes a sort of centre of infection, from which every year the fields are inoculated with the very disease which the farmer wishes to eradicate. Where it is prevalent, it is recommended to use artificials alone.

It is worthy of note, however, that super, on account of the acid it contains, is credited with being of great assistance to the development of the fungus. This brings us face to face with another difficulty, which may, to a great extent, be overcome by using a mixture of super and slag, or even slag alone. We can confidently recommend it to those who are troubled with the disease, for we are certain that if from other causes it is not altogether successful, there is no danger from the remedy itself, which is more than can be said of other boasted cures. Scarcity of potash in the soil is given as another cause, or as causing the plants to be attacked more easily ; but the direct application of potash manures has not, as a rule, given any decided results.

CHAPTER II.

MANGELS.

A contrast to swedes and turnips, though grown under similar circumstances—Can be made to yield enormous crops under suitable conditions of manuring, &c.—Farmyard manure a necessity—Seaweed good where obtainable—Much benefited by nitrate, also by potash manures and common salt—Suitable dressings and mode of application.

THE mangel has been called the root of scarcity in some districts, so well does it withstand drought, and keep green and flourishing when other crops are hanging their heads and looking anything but prosperous.

It revels in warmth, and does not succeed in moist cold climates, or in wet summers. Roughly, this fact determines the limits of its growth, for though it is found in isolated patches as far north as Aberdeen, yet from recent returns it appears that in 1894 only about 1,050 acres of land north of the Tweed were in mangel, as against nearly 500,000 in turnips and swedes. It is unfortunate that it is so uncertain a crop in the north and west, as the increasing liability of turnips, grown on the same land, to become affected by finger-and-toe, must, in any district where there is reasonable prospect of its succeeding, determine the increased growth of mangel. It is a most valuable

crop, providing abundance of food at a critical period of the year when fodder is often scarce; and for the production of milk in large quantity it has few equals, though, in common with all watery foods, it requires a liberal supply of concentrated food to be given with it, otherwise the quality of the milk suffers.

The mangel has a deep-rooting habit, and the capacity for making use of large quantities of manure. Where this is supplied, and the season is favourable, it produces enormous crops, upwards of 100 tons per acre having been grown. Some idea of the effect of season upon the crop may, however, be gathered from the Rothamsted results, in which a field similarly manured and treated varied in yield in different seasons from 6 to 27 tons. Not being fed on the land, the mangel is an exceedingly exhausting crop, especially when the great amount per acre is taken into consideration.

An ordinary crop of about 22 tons to the acre will remove in the bulbs

Nitrogen equal to $3\frac{3}{4}$ cwt. sulphate of ammonia.
„ „ $4\frac{3}{4}$ cwt. nitrate of soda.
Potash equal to 7 cwt. sulphate of potash.
„ „ 16 to 17 cwt. kainit.
Phosphates equal to 3 cwt. of super, 27 per cent.

The great difference noticeable between these amounts, and the corresponding demands made by turnips, is the large quantity of potash removed by the mangels. There is no great difference between the phosphates and nitrogen removed, but there is great difference in the amount of potash. When it is

taken into consideration that the crop under review is not a large one, and that only a comparatively small proportion of any manure is actually recovered in the crop, the necessity for liberal manuring is apparent.

Looking at the Rothamsted results, we are at once struck with the powerful effect of dung on the crop. Its use alone to the extent of 14 tons per acre gave a yield which in one year amounted to 25 tons per acre, on an average 15 tons, or about four times the amount realised without manure. This is not a phenomenal yield, but is remarkable when the conditions under which the crop is grown are taken into consideration.

With mixtures of artificials the results are very varied. With superphosphate alone, $3\frac{1}{2}$ cwt., the average yield was only slightly above that obtained without manure; while the addition of some $4\frac{1}{2}$ cwt. of sulphate of potash gave no increase. The inclusion of about $\frac{1}{3}$ cwt. of sulphate of ammonia with the super and the sulphate of potash gave only an average increase of about 1 ton per acre over that realised by superphosphate alone. When, however, the amount of sulphate was increased to nearly 4 cwt., or was substituted by 5 cwt. of nitrate of soda, this with super and sulphate potash gave a yield of 15 to 16 tons per acre.

It must be owned that these results are not altogether in accordance with those realised in ordinary practice, where it has been found possible to grow very large crops of mangels with artificials alone. The exhaustion of the land of vegetable matter, by the continuous growth of crops by artificial manure alone (an exhaustion which would not take place in

ordinary rotation), must be taken into consideration in reading these results. Not only is it found possible in practice to grow good crops with artificials alone, but it can be done at a lower cost than by the use of heavy dressings of dung, if the whole cost of the dung be charged against the crop.

The evidence of Rothamsted, however, is in favour of the use of dung for the mangel crop, and the general evidence of practical men is on the same lines. The very large crops are always obtained by liberal dunging, and further, it has constantly been noted that a crop which has been dunged will resist adverse circumstances much better than one which has been dressed with artificials alone. A striking instance of this was afforded by the results of experiments carried out for the Royal Agricultural Society. Several plots of mangel manured with artificials were grown along with others receiving farmyard manure, the plots forming part of a field the rest of which was growing a mangel crop dressed with dung and artificials in the ordinary way. While the plots manured with artificials alone failed, owing to the attack of grub and disease, the whole of the plots which received dung were a success. Whether the result was due to the dung acting as a sponge and retaining moisture, the experimenters were unable to say, but there was the result to speak for itself. The best results were obtained by the use of artificials *combined* with dung. The addition of nitrate of soda at the rate of 5 cwt. per acre to the dressing of farmyard manure gave an average increase of 6 tons over the farmyard manure alone, a result which contrasts with that obtained

with turnips which were not appreciably benefited by the application of nitrate of soda. Another point of interest is the *non-effect* of superphosphate when applied to this crop in conjunction with farmyard manure.

The addition of $3\frac{1}{2}$ cwt. of super to the dung in no case gave more than a few cwt. of increase, and occasionally resulted in decrease. The smallness of the effect of super alone has already been noted, and it is a general experience that deep-rooted plants, like mangels, are, to a great extent, independent of phosphatic dressings. Where, however, no farmyard manure was applied, the super had a better effect. The large amount of potash removed by the mangel would lead to the idea that dressings of potash salts would be useful; and this is so, provided other manures are supplied as well. For instance, the addition of potash salts to super was without result, but when potash salts were added to a dressing of ammonia salts and super there was an increase of 6 or 7 tons per acre. Where farmyard manure is used and the land is of a loamy or heavy nature, the use of potash salts, except in small quantities, is not necessary, as the dung itself contains a considerable amount of potash; but we are acquainted with one farmer who farms strong land, which should have abundance of available potash, who purchases and uses considerable amounts of kainit every year and speaks highly of the results. Where, however, land is light and free working, it is often deficient in potash, and a dressing of kainit or sulphate of potash gives capital results.

There is some question as to the use of salt as a

manure for mangels. Some declare strongly in its favour, while others as emphatically deny the possibility of any benefit resulting from it. So far as Rothamsted is concerned, no good results were obtained by its use ; but, on the other hand, and in view of the support it receives in many places, it is evident that its value is entirely dependent upon circumstances, and that each grower must, by trial, determine for himself whether it will be a good thing to use it in his district. In close proximity to the sea it would, of course, be superfluous, as the amount of salt carried by the wind even for some distance is considerable. The ancestor of the mangel was a sea-side plant, and doubtless revelled in salt, and its descendant is credited with having inherited the liking. Probably this fact is also in great measure responsible for the success which has attended the use of seaweed as a manure for mangel. Used in conjunction with dung—the land may be dressed with it in spring after an autumn dunging—it is most beneficial, as it contains a considerable proportion of potash. Indeed, the ash of seaweed was, until the discovery of large quantities of potash salts in Germany, the important source of this ingredient. Besides this, it contains phosphates and a considerable proportion of common salt. These fit it abundantly for manure for the mangel crop ; and when we consider the amount of vegetable matter added to the soil by a dressing of this manure, we can see that in districts where it can readily be obtained its sphere of usefulness need by no means be confined to this crop.

As dressings for mangel, keeping in view what has been already stated, the following are recommended. With dung at the rate of from 14 to 16 loads per acre—

2 cwt. nitrate of soda.
1 to 2 cwt. super.
2 to 3 „ kainit.

Upon some soils the kainit may be dispensed with, in which case a dressing of salt would probably be beneficial. If, however, sulphate of ammonia is used in place of nitrate of soda, the quantity of kainit may be increased, as it is found that with the slower acting sulphate, potash salts are more necessary. The reason for selecting kainit as the potash manure is that it contains about a third of the weight of common salt, an ingredient absent in sulphate of potash.

Where possible the dung for mangels should be ploughed in in the autumn and allowed to be thoroughly incorporated with the soil. The kainit, too, may be sown in the autumn with advantage. Where it is proposed to grow crops without farmyard manure, the quantity of superphosphate may be increased; or dissolved bones may be used, as they not only supply phosphate, but are a somewhat slow-acting nitrogenous manure, and thus help to make up for the dung. A dressing would be—

2 to 3 cwt. nitrate of soda or sulphate of ammonia.
2 „ 3 „ super.
1 cwt. dissolved bones.
1 „ bone meal.
3 to 5 cwt. kainit.

The feeding value of a crop of mangels is considerably affected by the manuring. The larger the crop, the longer it takes to mature; while smaller crops mature earlier and are relatively of higher feeding value. This is especially true of the bulky crops grown with heavy dressings of nitrogenous manures, which, bulk for bulk, have much less feeding value than the smaller crops grown with smaller nitrogenous dressings and with potash manure. The mangel is essentially a sugar crop, and depends in a great measure for its feeding value upon the amount of that substance which it contains. The bigger the crop, the lower the percentage of sugar, though it is only fair to state that the produce of sugar per acre is greater in a heavy crop than in a light one. Thus on the unmanured plot yielding about 4 tons per acre, an average of $10\frac{1}{2}$ lbs. out of every 100 lbs. weight of mangel was sugar; while on a plot manured with dung and nitrate of soda, which yielded some 20 tons, only about $6\frac{1}{2}$ lbs. out of every 100 lbs. was sugar. Then the true albuminoids of the mangel are very much lower in a crop which has been heavily manured with nitrate of soda or sulphate of ammonia, than in a smaller and more matured crop. These differences are not large enough to be of value where a few tons per acre is concerned, but they are sufficient to tell against extravagant manuring of any kind.

The juices of the mangel in its fresh state are injurious to stock, and no fodder needs greater care in its ripening before use than this. It is well on into spring before it can be used, but the liability to injury by frost is great, and so at the first sign the mangel

must be lifted and clumped. The top is wrenched off preferably to cutting off, and the clump must be so constructed that while absolutely preventing the danger of the roots being bitten, the heap may be ventilated, and thus loss by rotting be avoided.

CHAPTER III.

POTATOES.

An exhausting crop—Potato manuring a specialty—Potato growing in Scotland.

THE experiments on potatoes at Rothamsted have been in operation for twenty years, so that we may accept the information obtained therefrom as being the result of a thorough experience. The acreage under potatoes throughout the country in 1895 shows an increase of some 36,000 acres over 1894, but that year was below 1893 by 23,000, which, however, still leaves a net increase of 13,000 acres in this crop. Where a good market can be ensured, potatoes are a paying crop, but the constant fluctuation of prices adds an element of speculativeness and uncertainty. The average of the prices has fallen much of late years, and the regular supply of early potatoes from the Channel Islands has stopped the fancy prices for those varieties which would keep till May or June. The process of growing early potatoes in Jersey is a business of itself—of which we may have more to say later.

Though usually taking the place of a root crop in the rotation, really good crops can be grown imme-

diately following lea. The crop revels in the rich vegetable mould left by the grass, and capital yields, both as regards quality and quantity, are the result. We have heard many growers express their opinion in favour of this system, a south Yorkshireman being of the opinion that there was no comparison between potatoes grown after lea, and grown in the ordinary way as a fallow crop. The potato gives a smaller yield per acre than any other root crop, considering the amount of manure which is required to be spent on it.

At Rothamsted, with no manure, a steadily decreasing yield was observed; and in the last few years about 15 cwt. is all that can be got in this way. With farmyard manure alone, the yield at once goes up to about $4\frac{1}{2}$ tons per acre, which is in itself a very considerable increase. Neither superphosphate alone, nitrate of soda, nor sulphate of ammonia give a yield approaching this; and even a mixed artificial manure consisting of super, potash salts, &c., gave a yield of only three-fourths as large. When, however, the mixed artificial dressing was supplemented by nearly 4 cwt. of sulphate, or 5 cwt. of nitrate, the yield with farmyard manure alone was surpassed, the crop averaging about $5\frac{3}{4}$ tons. Farmyard manure, super, and nitrate of soda gave an average yield almost equal to this.

One thing is clearly shown by these results, namely, the necessity of a full all-round manuring for potatoes —without which there is little chance of a good crop. There is here no very striking evidence in favour of farmyard manure, nor indeed is there with any of the

root crops if weight of produce alone be taken into account; but though good crops of ordinary potatoes are grown without dung, it is indispensable for early varieties, and its almost universal adoption is sufficient proof of its good effect when growing the crop in the ordinary way. When, however, potatoes are grown after lea, the use of dung is not so essential; it is here that artificials alone give such good results.

In potato-growing districts like the Lothians, the amount of farmyard manure employed is tremendous, as much as 30 to 40 tons to the acre being applied. Whether these dressings are not excessive is a question, but such are the amounts regularly used. This applies only to those districts where potato growing is a specialty. In the majority of cases 12 to 16 tons per acre is a usual dressing. The supplementary artificial dressing should consist of superphosphate, nitrate of soda, and sulphate of ammonia with potash salts. The following mixture, applied with dung, at the rate of 4 to 5 cwt. per acre, is recommended:—

6 cwt. super.
4 „ dissolved bone.
1 „ bone meal.
5 „ sulphate of ammonia.
4 „ sulphate of potash.

Such a dressing, in addition to the dung, would cost about 22s. to 25s. per acre.

If no dung were applied, 8 to 10 cwt. of the mixture should be given. There is a fair proportion of potash in this dressing, and it is usual to include a good amount in all artificial manures for potatoes. Large

quantities are required, but with good dressings of dung, and on a fair loam or heavy land, the potash would probably not be necessary. If, however, the land were deficient in potash, its omission from the manure would severely prejudice the results. Potash manures, when added to land deficient in this ingredient, have the effect of hastening the maturity of the tubers, and producing sound and healthy potatoes, while sulphate of ammonia and nitrate of soda have the opposite effect where potash is deficient. The point as to whether this last is required must be settled by trial, as it is a pity to add to the expense of a dressing by including unnecessary material. Where potatoes follow lea the amount of artificials need not exceed 6 or 7 cwt. per acre.

So far we have treated the subject in a general way. We may now give one or two typical dressings from different districts which will show the manuring adopted, and also prove that fixed rules cannot be laid down as to the amounts of manure and the ingredients to be applied per acre. In Jersey, for early potatoes, 25 to 50 tons of farmyard manure are used per acre, supplemented by 8 to 12 cwt. of artificials of, say—

$5\frac{3}{4}$ cwt. of superphosphate (high class).
$2\frac{1}{4}$ „ sulphate of ammonia.

A couple of cwt. of dissolved bones may be used instead of a like quantity of super, in which case the sulphate may be slightly reduced, and 1 cwt. of guano used instead of a like quantity of sulphate of ammonia.

A common Scotch dressing is, per acre :—

15 tons dung.
3 cwt. super.
2 „ bone meal.
3 „ kainit.
2 „ sulphate of ammonia.

In Ayrshire, for early potatoes, the following dressings are adopted :—

20 to 30 tons dung.
5 cwt. kainit.
8 to 10 cwt. mixed phosphatic guano and sulphate of ammonia.

The following, typical of dressings in the Lothians, are quoted from the *Transactions* of the Highland Society :—

25 to 30 tons dung.
1½ cwt. guano.
2 „ kainit.
4 „ slag or superphosphate mixed.
1½ „ nitrate of soda.

Or either 20 tons of dung, a good dressing of spent hops, or 1½ cwt. of nitrate of soda.

The bearing of manuring upon the question of potato disease is one of great importance—one upon which too much stress cannot be laid, for, under favourable conditions, the disease spreads so rapidly that, within a few days, an apparently healthy crop alters in appearance until it looks as if severely frost-bitten. Closer examination reveals the presence of mould on the leaf, and on the potatoes the discolora-

tion so much dreaded by the grower. Sections of the tubers, even at an early stage, show signs of the disease, and later the whole of the interior becomes a dark brown mass. So far as Rothamsted is concerned, the results point to the fact that the greater the luxuriance of the crop the greater the tendency to disease. Thus, in the unmanured plots, the percentage of the disease was the lowest of any, averaging, during a period of twelve years, only 3.15 per cent. On the superphosphate plot, with a crop of twice the size, the percentage was only slightly higher—3.66. On that manured with mixed artificials, without nitrate of soda or sulphate of ammonia, with a slightly larger crop, only 3.45 per cent. were diseased. On the plots manured with nitrate of soda alone, and sulphate of ammonia alone, the percentage was much higher, averaging 4.93 and 4.06 respectively ; and with the complete mixture of artificials, which gave the largest yield, the highest percentage of diseased tubers was obtained.

In looking at these results, however, it is well to note that in the last case, where the percentage of disease was 6.26, the crop of sound tubers was more than 2½ tons heavier than that obtained with the mixed artificial manure, without nitrate of soda or sulphate of ammonia, and more than twice as large as that obtained with any single manure. With this in view, it appears that nitrogenous manures increase the tendency to disease, and that this tendency is increased more by nitrate of soda than by sulphate of ammonia. It is significant, too, that the mixed artificials without nitrate and sulphate of ammonia, though giving a higher crop, contained a lower per-

centage of diseased potatoes than superphosphate alone, a result which appears to be coincident with the admixture of potash manures. There is no doubt that where this ingredient is deficient, the admixture of sulphate of potash, or of kainit, in a dressing, by producing sounder, firmer, and healthier tubers, helps the crop to withstand disease. These results are no argument against full and complete manuring, but are rather opposed to excessive amounts of sulphate of ammonia and nitrate of soda in the manures used.

It is probable that a much more potent factor in the inducement of disease is the character of the season; that a damp summer and autumn, especially if at the same time the temperature be high, will be especially favourable to its development. This was very noticeable in 1896 when September was damp and hot. The disease went through some fields like a scorching flame, so rapid and complete was its attack. In this case the methods of prevention are more successful than many applied against fungoid pests. Diseased sets should on no account be used, and the diseased haulm should be burnt, so as to destroy the fungus. Then the crop should be sprayed at intervals during the year with the Bordeaux mixture. This is a mixture of bluestone and lime, in the proportions of 3 lbs. of bluestone to 1 lb. of lime, dissolved in 20 gallons of water. The bluestone is put in a muslin bag and suspended in water. The lime is slaked separately, and, when cold, added to the bluestone. The spraying may be done by any of the machines used for the purpose, and, where large quantities of potatoes are grown, this is the most economical way; but in certain trials made on farms

in Cumberland, a paraffin cask on a cart, fitted with a force-pump and four nozzles, sufficed for the application, and was declared satisfactory. About 100 to 150 gallons per acre may be applied, and care is necessary to ensure the complete drenching of the under side of the leaves, as the more completely every part of the leaf is covered, the better the effect. So far as is known there appears to be no virtue in this mixture as a cure; everything depends upon its being applied before the time of the appearance of the disease. In a good season one dressing is sufficient, but in bad or even average seasons two sprayings are required, given, say, at the end of June or beginning of July, and the second a month later.

The cost per acre of each dressing would be, according to the experience of the trials made by the Royal Agricultural Society, about 9s., and in the Cumberland trials the materials cost about 4s. 6d. per acre; so that, even with present prices, an increase of $\frac{1}{2}$ ton per acre would pay for the dressings, and in many cases the increase actually exceeded 2 tons. In the Cumberland trial, the increase ranged from $1\frac{1}{4}$ ton in the case of the Bruce—once sprayed—to nearly 4 tons in the case of Sutton's Abundance, the Bruce being the better disease-resisting variety. One noticeable feature of the crops in this case was that the sprayed plants kept their haulm for three weeks longer than the unsprayed.

A caution is necessary in reference to the application of the Bordeaux mixture after the disease has appeared. We have said that it will not cure disease, but if sprayed immediately after its appearance further progress may be stayed.

CHAPTER IV.

WHEAT, BARLEY AND OATS.

Wheat : Continuous growth of wheat with or without manure—Nitrogenous manures greatly increase the yield—Effect of present prices on outlay for manures. Barley : Requires more general manuring than wheat—Quality as well as quantity a necessity—Effect of manuring on this. Oats : Effect of manuring.

WHEAT.

WITH prices for wheat ruling so low, and wheat-land going out of cultivation every year, there is little to induce farmers to study the manuring of this crop. There are those who see in the slight improvement lately shown, and in other signs, definite promise of better times ; and though we do not feel that there is much indication of great improvement, still we hope that with natural brightening of trade, and the suggested aids to agriculture, the relative value of wheat along with other produce may be increased ; and that this crop, to the growth of which so many lands are suited, may once more become remunerative. Sir John Lawes expressed it as his opinion that the experience of Rothamsted led him to the conclusion that with present prices it would pay better to grow

small crops of wheat than large ones. By this he no doubt meant that the cost of increasing a good crop to a better one was so much higher than the cost of increasing a poor one, that after a certain standard, and that not a very high one, the increase in crop did not pay for the extra outlay in manures; and that where the crop is grown in the ordinary way after clover or seeds, the manure actually applied to the crop should be small in amount;—such, no doubt, is a very general experience. Professor Wrightson, however, writing on this subject, advocates the growth of full crops of wheat, on the ground that otherwise the whole rotation and the capacity of the farm must suffer.

Wheat is the crop of all others which can make the most of the inherent fertility of the soil without the application of large quantities of manure. Its deep-searching roots bring up supplies from every part of the soil. At Rothamsted the continuous growth of wheat for fifty-three years on the same soil without manure has become historic, and the fact that 8 or 9 bushels an acre are still grown proves the capacity of wheat for making use of the soil material.

For all that, however, this yield is in striking contrast to that obtained by various manures. Farmyard manure—14 tons—has given an average of 34 bushels per acre during the forty-two years which it has been applied, and in 1894 gave a yield of 45½ bushels. The weight, too, has averaged the respectable amount of over 60 lbs. per bushel.

Looking at the results obtained with artificials, the effect of nitrate of soda and sulphate of ammonia was

very marked ; but mixed artificials without nitrate of soda or sulphate of ammonia gave but little result. A mixture of artificials with nitrate of soda or sulphate gave the highest yield obtained, viz., 55 bushels, in 1863. It is only fair, however, to state that the general average is much the same as that with farmyard manure, showing that artificially-manured wheat is more subject to fluctuation than that dressed with farmyard manure. Probably the best dressing for wheat is well-dunged clover or seeds. Dung is a grand manure for these, and by applying less dung to the root break, as recommended when dealing with the manuring of swedes and turnips, more would be available for this purpose. The residue left by the clover is rich in nitrogen gathered from the air, and this residue, with the remainder from the dung, is conducive to the growth of wheat crops of the highest quality and quantity. Even with land in such condition, the addition of nitrate of soda as a top dressing has a marked effect on the quantity of the crop, and, if the season be favourable, has no bad effect on its quality. Otherwise, however, the grain may be late in ripening, and the extra manuring give no return. Where nitrate of soda is used it is best to add 1 to 2 cwt. of kainit, as this is the best thing to use in conjunction with nitrate to check over-luxuriance, and though slag or super is often recommended, the deep-rooting habit of wheat makes it, to a great extent, independent of phosphates.

It was noticed in the Rothamsted rotation experiments that wheat after bare fallow gave practically no higher yield than wheat after beans or clover, so that

except where fallow is rendered absolutely necessary by circumstances, it cannot be considered as paying.

Barley.

The manuring of barley may be regarded as all-important, seeing that so much depends upon the quality of the grain. The object for which much of the barley is grown is malting, and as the highest quality is required for this, the bearing of manuring upon quality is a great matter. We have in barley a crop which occupies the land a much shorter time than wheat, and though, like that crop, it is dependent upon nitrogenous manures, its period of growth and shallower rooting habit make it more dependent upon other manures.

There is a feeling that the use of artificial manures is detrimental to the quality of the grain for malting purposes, and this doctrine is widely preached. Mority deals with the question in a paper read by him in June 1895. In it he refers to the value of the various samples of barley grown on the Rothamsted plots. Here the best samples have been grown with artificial manure, those obtained in the ordinary course of rotation being generally greatly inferior. The quality is largely dependent upon the ripeness of the crop. If the manuring is heavily nitrogenous, the maturing of the grain is retarded, and the quality of the produce is likely to suffer; but if a well-arranged mixture is employed there is little danger of this.

It must be owned, however, in reference to this, that the produce of the plots at Rothamsted, which were continuously manured with dung, have given

the highest average, viz., 48 bushels for forty-two years, also that the average weight per bushel is as great as that of any other of the plots, viz., over 54 lbs. The nearest approach to this yield is one obtained by the use of a complete artificial manure, with nitrate of soda containing about 2½ cwt. of nitrate, and nearly 2 cwt. of sulphate of potash and sulphate of magnesia. This manure has given an average of over 46 bushels per acre, and the weight upwards of 53 lbs. per bushel. A mixture of 2½ cwt. nitrate with 3½ cwt. of superphosphate gave a yield almost equal to this, and the weight per bushel was nearly the same.

Where barley was grown in ordinary rotation after roots, the produce of the crop was materially affected by the treatment accorded to the first-named crop. The better the crop of roots the heavier the yield of barley, though very fair yields of the latter were obtained without the application of manure to any crop in the rotation. The yield of barley was very much higher on those plots where the roots were fed off on the land than on those where they were carted.

Where heavy crops of roots are fed, it is often found that the condition of the land is such as to prohibit the growth of barley of the highest malting character, except in seasons of exceptionally favourable character. In this case it is better to take a crop such as wheat first, and then follow it with barley, as barley grown in this way is almost always of superior quality. Where this course is adopted it will generally be found advantageous to apply a little artificial manure. A suitable dressing would be 1½ cwt. to

3 cwt. of super, and about ½ cwt. of nitrate of soda. The last should be top dressed on the braird. Nitrate is a much better manure than sulphate of ammonia for barley, and in small quantities may even be used with advantage when this crop follows roots.

OATS.

In some respects this crop is at present the most important of the cereals, and as such the effect of the various manures on it is interesting.

In the North it takes the place of the wheat crop, following seeds or lea. In this case it is not general to manure, but experiments have shown that under certain circumstances it may be desirable to do this, and the benefit thus derived was well shown by last year's trials of the Highland and Agricultural Society, of which we shall speak later. At Rothamsted, nitrate of soda alone gave very good yields of grain, especially in the early years, when the land had not become impoverished by continuous cropping. The weight of straw, however, was not so great in the case of nitrate as in that of sulphate of ammonia The result of the dressing of complete artificials was much the same as with barley. The balance was slightly in favour of sulphate of ammonia over nitrate of soda, and in one year (1869), with sulphate of ammonia, super, potash, and magnesia salts, a yield of 75 bushels per acre was obtained. Of course, this was exceptional, but several times the yield topped 60 bushels. The dressing was very heavy, being about 3¾ cwt. sulphate of ammonia, 3½ cwt. super,

nearly 2 cwt. sulphate of potash, and 1 cwt. sulphate of magnesia.

Extensive experiments were made last year in Scotland on the manuring of lea oats, with the object of discovering how best to improve the crop, especially on somewhat poor soils, without impairing the strength of straw. The manures applied were—

Super, - - - -	3 cwt. per acre.
Muriate of potash, - -	1½ „
Common salt, - - -	3 „
Nitrate, - - - -	1 to 1½ „

alone, and mixed with one another.

The nitrate was in some cases applied with seed, in others on braird, and in every case it proved superior when applied on the braird. It was also superior in every case to sulphate of ammonia although the season was wet, a result somewhat unexpected. The muriate of potash applied had a capital effect on the crop, though the land was a heavy loam with clay subsoil. In every case where this was included the crop was heavier, and was also earlier than in the other cases. Nitrate of soda and super gave a disappointing return, but the addition of muriate of potash improved both the quality and the quantity. A very striking result, and one to which special attention was called, is that obtained by the addition of 3 cwt. of common salt to the super and nitrate. This was a special feature of the trial, and the result came as a complete surprise; for not only was the quality of the crop improved by the salt, but the yield both of grain and straw was much increased.

It appears from this that where nitrate of soda and super are employed there is risk of the crop becoming laid, and that the admixture of muriate of potash, or of common salt, will to a great extent counteract it. That the salt has at the same time no detrimental effect was shown by its increasing the yield. Seeing that common salt had such a good effect, we should recommend kainit instead of muriate of potash, as it contains the potash salt and common salt as well. Such a dressing would be, say—

Nitrate, - - - -	½	cwt. per acre.
Super, - - - -	2	„
Kainit, - - - -	2	„

It would appear from these trials that, at any rate on poor soils, the manuring of lea oats will pay, for in the above the nitrate, super, and salt gave an increase of half as much again over the field which got nothing; and the nitrate, super, and muriate of potash gave a yield even slightly higher.

CHAPTER V.

FORMATION OF GRASS LAND.

Present tendency towards increase of pasture—Systems of laying down land to pasture—Lord Leicester's methods in East Anglia—The going off of pastures—Renovation of pasture.

THE tendency of recent years to lay down land to grass wherever possible is still maintained, if statistics may be taken as a guide. Probably, as has been often pointed out, there is much land scheduled as having been laid down to grass which never reaches that state, but is ploughed up again as unprofitable within a few years of its having been laid down. Still, making due allowance for this, there is evidently an increased desire to put down land to grass wherever it will carry it, and at present prices and conditions it is often the only course open.

Mr J. Caird, in an article in the Royal Agricultural Society's *Journal*, points out that a great deal of the land now being laid down was broken up when the price of corn made it profitable to have every possible acre of land producing that crop, and that it is merely a reversion to the old order of things that is manifesting itself. Unfortunately, as is pointed out in the

same article, upon much of the land then broken up it is almost impossible to get a good turf. Many of the heavy soils on dry, harsh climates, and on which corn-growing has become unremunerative, practically refuse to become pasture; and the same may be said of many of the light soils in drier districts, which were sheep walks before they were ploughed up. The reversion to pasture is extensively deplored by those who see in it the possibility of future danger to the country; but whatever truth there may be in this, so long as present prices are maintained, so long will more land go out of cultivation; and if some of it has to be broken up again, the system of alternate husbandry thus induced may become of great benefit on soils of lighter character, for such a system of temporary pastures is one of the best ways to meet present exigencies. Though allowing land to go out of cultivation is spoken of as the only alternative in the existing state of things, good permanent pastures are not to be obtained without expense. On the contrary, the outlay is often considerable, and in no case can the end be accomplished without a great deal of trouble as well.

There are three things to be taken into consideration in the formation of pasture—condition of soil, seeds and seeding, and management. Lawes and Gilbert long ago pointed out that permanent grass land was a store of fertility; not that the fact was new even then, for the adage that "To break a pasture will make a man" had foreshadowed it. Every year the remains of dead plants add their quota of fertilising material, parts are collected at varying depths from

the soil, parts from the air, and how great that amount may be was proved by the investigations at Rothamsted. These showed that in a period of ten years (1879-89) the nitrogen gained by the surface soil (first 9 inches) of a field newly laid down to "permanent grass" was about 50 lbs. per acre per annum —an amount represented by over 2 cwt. per acre of sulphate of ammonia; and this in spite of the fact that full crops of hay had been removed.

It is impossible to conceive that this accumulation of fertility can come about without the most liberal management, and the more quickly this condition is arrived at the sooner will the pasture be an accomplished fact. That success depends greatly upon subsequent management is undoubted, but that on this account the condition of the land at the commencement can be neglected is an error. The higher the condition the better the chance of ultimate success. Roots fed off with sheep receiving dry food usually leave the land in suitable condition; but if the roots are carted, the exhaustion should be made good by liberal manuring with farmyard manure.

There are a great variety of systems of laying down land to grass, each possessing its own peculiar merit. Some authorities recommend seeds being sown with a corn crop, others seeding without; some favour autumn sowing, while others are equally strong on spring sowing. Circumstances must determine procedure to a great extent; but in the main, opinion seems in favour of spring sowing on a light corn crop (of which wheat is the best), as this allows more light and air to the growing crop, and stands better. The

stubble, if left fairly long, affords shelter to the tender plants, and the crop helps to pay expenses.

There are circumstances, however, especially where cost is not of the first consequence, where it is better to seed without a corn crop. A few years ago we remember seeing on the same farm two fields which had been laid down at the same time. One had been sown on a corn crop in the ordinary way, the other without a crop, according to De Laune's plan. The latter gave every promise of making an excellent pasture; the former was about being ploughed up as a failure.

There is another point on which authorities disagree, and that is as to the permanency of perennial rye grass. There is no doubt that in certain districts and on certain soils it is permanent; on the other hand, it seems equally certain that there are situations where it is not permanent; hence the difference of opinion. On this account there are authorities who advocate its omission from all mixtures for permanent grass, on the ground that the money might be better spent on other varieties. Rye-grass, however, gives such abundant yield the first two or three years after it is sown, that, even where it is not apparently permanent, it is desirable to include a fair quantity in the seeding, as it will yield well while the other grasses are establishing themselves. Of the various mixtures of seeds recommended under different conditions of soil and climate much might be said, but so many are the points bearing upon the subject that it is impossible to dwell upon it here. Arbitrary rules cannot be laid down, and unless the farmer has had considerable experience,

it will be well to place himself in the hands of a reliable seedsman, giving him particulars as to soil and position.

Where, however, much land is to go into pasture, observation and trial will soon decide the most suitable grasses, and mixtures can then be arranged by the cultivator himself, with great benefit to both pocket and pasture. In examining old pastures care is necessary, for an abundant grass is not of necessity a desirable one to use largely in mixtures. We often see pastures covered with "Yorkshire fog," which is worthless enough, and only makes such a brave show because it is refused by stock; and crested dogstail often develops rapidly for the same reason. Whatever be the mixture adopted, only the best seeds should be employed, for nowhere is the expression "cheap and nasty" more applicable. No seeds are so easily spoilt, or so easy of adulteration, as grass seed. Cheap mixtures are dear at any price, and often consist of damaged or old seed, which, of course, is useless. Light seed is to be regarded with suspicion, and for that reason weight should be taken into consideration as well as measure. Indeed, no seed should be bought without a proper guarantee as to its genuineness and germinating power. Farmers had better sweep their own hay-lofts, or allow the land to "tumble down," than buy cheap seed from unknown men.

In sowing, a fine seed bed is essential, for on a rough uneven surface the small seeds are liable to become buried too deeply. The land should be fairly dry at the time of sowing, and the seed-barrow should be used. It is a good plan to sow the light (true grass)

seed first, and to cross the heavier seed (clover) afterwards, by which means equality of sowing is secured. If the seeds are all mixed together it is difficult to make the mixture complete, and after the seeds are once mixed, each shaking tends to separate the compact, smooth clover. A light harrowing may follow, but in some cases rolling merely is sufficient. The object is to ensure complete covering of the seeds without burying them too deeply.

With all care in the selection of seed, and in seeding, only unsatisfactory results will be obtained unless the after management is conducted with care and sagacity, and with a generous hand; no niggardly policy will succeed. Should weeds become plentiful before the young grass is established, they should at once be got rid of, and that before they can seed, otherwise they will be a great source of annoyance at a later date. The grass should be allowed to grow unchecked during the first autumn, although there is considerable temptation, where it is making a good show, to make use of the excellent fodder thus afforded. If this is done, pasturing lightly with young stock is all that is admissible. Sheep graze much too closely, and are liable to injure the young plants. In the autumn a dressing of dung may be applied and lightly broken with the chain harrow; and should dung be scarce, a portion of what is usually devoted to the turnip break may be used for the purpose. In the ensuing spring the pasture should have a thorough rolling; indeed, the young grass can scarcely get too much attention of this sort, and no stock should be put on, but the grass allowed to grow for hay. It

should be mown early, before the grasses have flowered, or at the latest before they have passed the flowering stage ; and though this early mowing may somewhat prejudice the hay crop, it is better so than that any risk should be run of losing the so-called permanent grasses by allowing them to seed. In the autumn the field should be again dressed with muck, and the next and subsequent years stocked with cattle getting cake. The higher the feed given to the stock the better chance the pasture will have. The loss of phosphates, which continual pasturing with young or milking stock renders liable, may be made good by occasional dressings of super, dissolved bones, or basic slag, and kainit may also be given with advantage. It is almost invariably in the after management that the failures occur. It is waste of money and labour to buy the best seed, and take every possible care in the early stages, if afterwards the young pasture is stinted. A well-known agriculturist has stated that a pasture can be made anywhere, provided only the treatment is sufficiently liberal ; and though this is probably somewhat of an exaggeration, there is no doubt that it contains the keynote to success. Nor need this of necessity be such a great expense, for the extra field will always enable the land to carry more stock, and there are not wanting examples of land having been laid down at a profit. The field of Dr Gilbert's, already mentioned, was laid down to grass and mown regularly every year, a form of treatment not calculated to give the best results ; and by judicious treatment, with heavy dressings of dung alternated with small amounts of artificials, the meadow was formed,

and there was actually a balance in favour of the field at the end of twenty-three years; and this in face of the fact that the soil was not specially suited for pasture, nor was it in the best of condition.

There is a prejudice against using artificial manure on a pasture while it is forming. One cannot beat dung or the droppings of cake-fed cattle, but there is often a scarcity of dung for the purpose, when recourse may be had to artificials with good results. We have mentioned Dr Gilbert's field, which was from choice manured with artificials and dung alternately, and the result was satisfactory both as regards the quantity and quality of the produce. A great deal depends upon the manure employed. Artificial dressings should contain phosphate, nitrogenous and potash ingredients. There should not be heavy dressings of nitrate of soda and sulphate of ammonia alone. In the case cited above, the artificials consisted of $\frac{2}{3}$ cwt. each of nitrate, super, and kainit every alternate year; the other year the dressing was 9 tons of farmyard manure. In many cases it has been found advantageous to vary this. The proportion of super and kainit may be increased, or dissolved bones may be used, as being an excellent manure for grass land.

It may be objected that such liberal treatment is often impossible. We can only say that this is the way to achieve the best results, and that the time taken in the formation of a pasture may often be shortened by one-half by so doing, if it is obtained at all by other treatment. If a farmer is not prepared to deal in this way by his new pasture he had better

abandon the idea, and not waste time or money, for in very few places will success be achieved.

After a time, varying with circumstances, a newly-formed pasture often "goes off" considerably, and unless carefully looked after may fail altogether. M. De Laune attributes this to the dying out of temporary grasses before the others have fully established themselves, and he attempts to overcome the difficulty by using only what he is convinced are permanent grasses. It is certain that he has been most successful with his pasture, but that this is not due entirely to the selection of the seeds is shown by the extent of his outlay on manures. Where bare patches appear in the fields these should be sown down with a renovating mixture, the ground being scratched with a hand-rake if the patches are small, with harrows if large ; and afterwards a full dressing of dung or good mixture of artificials, or, better still, an autumn dressing of compost should be applied, to be followed by cake-feeding the following year. There seems to be something in the mixed compost which makes it particularly adaptable to renovating or assisting pastures, and if obtainable its use cannot be too highly recommended. The after treatment will be on the lines indicated in the formation of pasture, and improved management will work wonders with apparently worthless material.

CHAPTER VI.

GRASS LAND, MANAGEMENT AND MANURING.

The policy of manuring for the hay crop—Messrs Lawes and Gilbert's experience.

In the last chapter we spoke of temporary pasture as an alternative to permanent pasture as a means of meeting present depression, and in the present chapter we purpose dealing with the same subject at somewhat greater length. The plan is practised with much success throughout the North of England and the Lowlands of Scotland, the period that the grass is allowed to lie varying with the districts, and we feel certain that this method might be adopted to a still greater extent. It has the advantage of being suitable on the lighter classes of soils where permanent pasture is extremely difficult to obtain; but these soils are by no means the only ones upon which temporary pasture is successful, as heavy loams are extensively cultivated on this system. The heaviest soils, unfortunately, are so expensive to clean after several years of grass, that temporary pasture is not altogether to be recommended on them. Two years grass, however, materially diminishes the working expenses of a farm, without leaving the land nearly so foul. The difficulty of

cleaning, and the prevalence of wire-worm and grub, are the great preventives of a more extensive adoption of the system. Speaking on this subject with a neighbouring farmer, he expressed his opinion that the foulest field could be cleaned by growing a heavy crop of rape, feeding lightly, and then ploughing in; and this method is practically the one adopted by the Earl of Leicester on his light lands in Norfolk. The noble Earl described his system in the *Times*, and as it excited a good deal of attention and was much discussed, it may not be out of place to refer to it.

In this scheme, sheep feeding is the great object, and 40 to 50 acres of grass are annually broken up, and as many laid down, in temporary pasture. The grass remains for eight years, and the store of fertility thus accumulated enables the land to grow four crops in succession *without the application of manure.* When the pasture is broken up, it is ploughed in the winter, cross-ploughed a few weeks later, and knocked about during early summer; this has the effect of killing the turf and couch. The turf is turned in in July, pressed by a drill roller, and a crop of turnips or rape sown. This plan of following immediately with a root crop is a typical feature of the system, as such a crop, by its luxuriant growth, effectually prevents the spreading of weeds, and the land is clean during the whole of the rotation.

The usual course of cropping after the breaking up is rape, oats, turnips, barley. The barley is seeded, and the grass remains again some seven years, accumulating once more the fertility which the cropping has removed. In the mixture employed there are one or

two significant points. The amounts are much smaller than are usually used, and though the best quality seed is employed, the cost is only about 12s. or 13s per acre. We append the mixture as being typical, but it must be noted that it would not suit all soils:—

Cocksfoot, - - - - -	4
Perennial rye grass, - - -	2
Italian rye grass, - - - -	2
Timothy, - - - - -	1
Tall oat grass, - - - -	1
Golden oat grass, - - - -	¼
Meadow fescue, - - - -	2
Hardy fescue, - - - -	1
Alsike clover, - - - -	1½
White clover, - - - -	1
Yarrow, - - - - -	¼

We are of opinion that one chief reason of the success of the above mixture is that the grasses included are admirably suited to the particular district, and that equally small amounts would do elsewhere, *provided the same care were bestowed on the selection.* The rye grass, timothy, cocksfoot, the clovers, and perhaps the fescues might find a place in any mixture; but the oat grasses, which are included because they are specially suited to the district, might be left out in many places and substituted by more suitable species, such, for instance, as the meadow grasses. It is as essential here as in dealing with permanent pasture that a mixture suitable to soil and climate be used, and we are of opinion that failure has more often resulted from neglect of this than is generally supposed.

In the management of pasture this system departs somewhat from the general rule. The grass is mown the first year, but after that is pastured regularly by sheep, as the fences are not strong enough to turn bullocks, and as there is other pasture strongly fenced on the estate. The second year or so care is taken that the pasture is not eaten too closely.

Writing on this subject, however, Lord Leicester expressed it as his opinion that light feeding by bullocks would be better for the first year or two, if there had not been sufficient well-fenced pasture on the estate to make it undesirable to fence this portion in more expensive manner. He is of the opinion that were the light land on many farms treated in this way it would enable farmers to keep ewe flocks where now it is impossible. The best method of obtaining and making use of extended temporary pastures is so well set forth in Lord Leicester's description, of which we have given an abstract, that there is no need to further enlarge upon it.

The manuring of pasture and meadow is a subject which affords at once an opportunity for enterprise and for the display of knowledge. To get the maximum yield, and yet not deteriorate the quality of the produce, is an object to attain which requires a very thorough knowledge of the action of the various manures. The herbage of a meadow or pasture is so varied that great care is required in the application of manure, so that one or two species be not encouraged at the expense of the others.

There are those who maintain that it does not pay to manure permanent meadow—that you should go

on removing crop after crop and put nothing back. Such a policy is suicidal. Messrs Lawes and Gilbert have shown the folly of such a contention, and they prove that if the manuring is suitable the increased crop of hay considerably surpasses in value the outlay on the manures. The mixture of manures used by Dr Gilbert on his meadow is difficult to improve upon; but we will give some of the other results obtained at Rothamsted in the manuring of "permanent meadow." The experiments in this direction have been considerable; they have been in progress over forty years; and the plots present a very varied appearance under the different manures, for the herbage has become extensively altered, a point upon which we shall enlarge later.

So far as mere bulk of produce is concerned we note the following: Taking the whole time during which the experiments have been in progress, the highest yield of hay was obtained from a complete dressing of artificial manure, which was applied at the rate of about 15 cwt. per acre, and consisted of—

Nearly 5 cwt. of sulphate potash.
„ 1 „ sulphate soda.
„ 1 „ sulphate magnesia.
„ $3\frac{1}{2}$ „ super.
„ 5 „ sulphate ammonia.

This is an exceptionally heavy dressing, but the yield in 1894 off this plot was nearly 84 cwt. This is 55 cwt. more than the unmanured field gave the same year. If we take the average from 1876 to 1892, we find that the yield of the unmanured had

averaged about half that of the one receiving the above treatment. The addition of silicate of soda gave a fairly substantial increase, but its use is not of much practical import. The omission of ammonia salts was characterised by a considerable reduction in the amount of produce, but the substitution of nitrate of soda again raised it, though in these trials nitrate of soda did not give such good results as sulphate of ammonia. It would be unwise to argue from this that sulphate is a better manure for hay than nitrate of soda, for the difference is not great, and general experience is opposed to such a conclusion; indeed, even in the present case when applied *alone*, the advantage was decidedly on the side of the nitrate. Superphosphate alone gave but a moderate increase, but the addition of sulphate of ammonia to the super was a great improvement.

On the whole the general conclusion is that a good even mixture containing potash, phosphate, and nitrate or ammonia, is the best, and if this is alternated with dung so much the better. The proportion of nitrate or ammonia may be somewhat larger than that of the others, as this will have a marked effect on the amount of produce. Some buyers have a great objection to heavily nitrated hay, especially if it is required for horses doing fast work, or for hunters. They do not like the overgrown rank grass produced by heavy dressings of nitrate alone. Where, however, nitrate is used in conjunction with other manures, not only the quantity but the quality is increased. Nitrate of soda then should not be used alone. Nothing will sooner spoil the character of the herbage of a

meadow than so doing. Recently we heard a farmer complain of the entire absence of clover upon a meadow on his farm. We inquired into the treatment, and found that it was getting an annual dressing of nitrate and nothing more. He could have hit upon no safer plan of preventing the growth of clover, for it will have nothing to do with undiluted nitrate.

The effect of manuring upon the character of the herbage is an all-important factor, and we know of no more instructive sight than that obtained when walking along the variously manured plots at Rothamsted. It is like going from one district to an entirely different one to step from plot to plot, for the continuous manuring on stated lines has so altered the appearance and character of the plots that it is difficult to believe that forty years ago they all formed part of the park, and that the herbage on each was similar. Both the nitrate and sulphate of ammonia plots were a peculiar green colour; the herbage was almost entirely grass, and that of but few species, coarse and rank; it had a decidedly immature appearance, and lacked fibre and substance. There was total absence of clover and allied plants, and what was more striking, the dividing line between one of them and the next plot, which was receiving a mixed artificial dressing, was clearly shown by the limit of the growth of a vetch, which was abundant on the latter, but refused to cross to the one manured with nitrate of soda.

Another striking proof of the same effect was afforded by a plot which had been continuously manured during the early years of the experiments

with ammonia manures. There was the usual result, a somewhat diminishing bulk of produce, coarse rank grass, and no clover. As only a comparatively small proportion of the added manure was recovered in increase of crop, it was resolved to discontinue this manuring, and to apply a mixed artificial dressing without ammonia, and see if any of the manures added on previous years still remained in the soil. So far as the residue of the manures previously applied was concerned the experiment was a failure, but an almost immediate result was a change in the character of the herbage—a change decidedly for the better. The number of kinds of plants found on the plot increased, and, what is better, there was very soon a welcome intermixing of clover. The inclusion of potash manures—kainit or sulphate of potash—has an excellent effect on clover, and it may well be included, even in a dressing for heavy land where potash is usually supposed to be abundant. More than that, we strongly advocate potash manures being applied wherever nitrate of soda or sulphate of ammonia is used.

In conclusion, we would emphasise the following points. That dung is an excellent manure for meadow, as it not only increases the yield, but acts beneficially on the character of the produce; that the addition of artificials, however, greatly increases the yield, though probably the best way is to alternate the dressing—dung one year, mixed artificials the next. That nitrate of soda alone should not be applied but always in conjunction with potash and phosphates; and that about $\frac{3}{4}$ cwt. per acre of nitrate

of soda or sulphate of ammonia is as much as may be with safety included in a dressing for a meadow of mixed quality if the herbage is to be maintained. Where, however, bulk of produce is the object the amount may be increased, and if the quantities of kainit and super be at the same time augmented, though the produce will contain very little clover, it will not at the same time become so rank and coarse as that given by nitrate of soda alone.

CHAPTER VII.

GRASS LAND, MANAGEMENT AND MANURING—Continued.

Effect of different mixtures of manures on quality and quantity of the produce of meadow—Increasing clover by manuring—Nitrate of soda alone a bad thing.

In the chapter on the formation of pasture we dealt briefly with manuring during the first few years, and we now propose treating of the subject at greater length, especially with respect to the use of artificials.

The regular depasturing of animals makes great demands upon a soil, and though this demand is least in the case of fattening animals, even here it is by no means inconsiderable. Upon some soils the feeding of cake appears to be sufficient to keep up quality, and so long as only fattening stock are kept this will probably answer. In most cases, however, this is not enough to supply the needs of the pasture, other manuring being necessary, and it will be our aim to point out the most suitable artificials for the purpose. Farmyard manure we have already dealt with.

There is no crop which offers such a good opportunity for the display of intelligence in the use of manures than permanent pasture, nor one in which

the cultivator can more easily make mistakes; and yet it is one on which it is the simplest thing in the world to make a preliminary trial of a proposed manure before dressing a larger area. We have not unfrequently come across cases where manures applied on the recommendation of other farmers have been almost barren of result. The one who applies them naturally feels annoyed and disappointed, but having spent his money he cannot afford to try another dressing in the hope that it may answer better; he has to solace himself with the cold comfort that the material he applied is probably in the soil and may benefit him at some future time Had he, however, first tried a portion of the field he would have seen whether the whole was likely to be benefited. Many a useless outlay would be saved were this plan adopted.

The Highland and Agricultural Society conducted a number of experiments on the manuring of pasture land, and as the results have been carefully recorded they are of great interest. In the manuring of a pasture, quality rather than quantity of produce is the aim; and in the records of these trials we have not only notes of the appearance of the pasture, but also the way in which the produce was eaten by stock—a sure test of quality. In previous years these plots had been cut for hay, making a comparison possible as to the value of certain manures for hay and for pasture.

The scheme of the experiments was as follows:— Trials were made of phosphates, nitrogenous and potash manures. In testing the phosphatic manures, each plot, except one which received bone ash alone, was dressed with nitrate and potash, and a different

phosphatic manure was applied to each plot. In testing nitrogenous manure, super and potash salts were added to all the plots save one, which received nitrate of soda alone, and the nitrogenous dressing was varied. In the same way with potash salts. The potash manure was varied, while each plot received nitrate and super, except one, which received potash dressing alone. Three different guanos were tried, and three qualities of superphosphate. As mentioned, these had been applied for the hay crop of previous years. Notes, however, were kept of the plots when they were pastured, so that information might be gleaned as to the effects of these different manures on grass which was being eaten off.

Referring to the detailed results, we find that bone meal was a great success. As a manure for hay it had not answered well, but as pasture manure its value was unmistakable. Its slow action was eminently suitable for this. There was abundance of grass and of clover, and, what is more, the cattle grazed it regularly and closely. The report speaks of these plots as among the freshest, greenest, and most barely eaten plots on the station. Unfortunately, it is not upon all soils that bones will answer; on limy or sandy soils they take too long to decay, if they ever decay, and hence are of little use; but on heavier soils or loams, where they decay rapidly, they are undoubtedly one of the best manures obtainable. Quite the reverse was the result with superphosphate. It had done fairly well as a manure for hay, but under these circumstances it was far behind the bone-meal plot, and was avoided by the stock.

Ground mineral phosphate, which is never in much repute as a manure, was slightly better, and basic slag gave a very fair result. We are of opinion that there is a tendency to overrate the powers of basic slag, for it seems in danger of being regarded as a sort of universal infallible manure in its power of restoring grass land. It scarcely appears to be well understood that though undoubtedly an excellent manure, there is a possibility of its being out of place, that it supplies nothing but phosphate and some lime, and that if the land be wanting in nitrogen or potash, slag will not supply it. On the plots which had been dressed the previous year with nitrate of soda and super and potash, there was a fair show of grass but little or no clover, and the cattle avoided it. Here is a matter of importance. The nitrate had induced a full growth, but, as the stock left it alone, to no purpose.

Where sulphate of ammonia had been the nitrogenous manure applied, the absence of clover was not so marked, but even this was by no means relished by stock. Where, however, slower acting nitrogenous manures had been used—dried blood and horn dust—there was a great contrast. Clover appears to have no such dislike to these slow-acting substances as to nitrate and sulphate of ammonia, and the mixed herbage on these plots was excellent as regards quantity and was well eaten by the stock. It is noteworthy that these manures had given but poor results when used for hay, though slightly better results than bone meal. The plot previously manured with nitrate of soda alone was a complete failure. There was no clover on it, the grass was scanty, and what little there

was was entirely refused by the stock. The poverty of the plot is explained by the fact that nitrate gives all its result in the first year of application, so that that there was practically no residue from this manure. In short, it is evident that for pasture nothing can equal the slowly-acting nitrogenous manures for favouring a mixed herbage of excellent quality. The plot which had received nothing but potash salts, and which had been an utter failure for hay, had a fine display of herbage, a good quantity of clover, and was well eaten.

The guanos—Ichaboe and Peruvian—gave fairly good results, but the best result was achieved on the plot hitherto manured with fish guano. In the words of the report, "It was closely grown in with grass and clover beautifully mixed together, . . . it looked more like a lawn than a pasture." This result is not to be wondered at when we take into consideration the composition of the fish guano, a good sample of which would yield 10 per cent. of ammonia and twice that amount of phosphates, and being a slow-acting manure it agrees with the experience gained from the plots manured with nitrogenous manures. We could conceive that this manure, used in conjunction with an occasional dressing of kainit in the autumn, would be a capital manure for pasture—as the kainit would supply the only ingredient in which the fish guano is deficient.

In concluding the report on the general manuring, it is noted that the larger the amount of soluble nitrogenous manures—nitrate or sulphate of ammonia—the less the clover, the coarser the grass, and the more imperfect the grazing of the plots.

Concurrently with these a number of trials were instituted at different places to ascertain the value of slag, gypsum, kainit, and green vitriol, both singly and in combination, as pasture manures.

The best of these plots, the most closely grazed, and the one which showed the highest percentage of clover, was manured with slag, gypsum, and kainit. The manures, which were applied in March, amounted to 6 cwt. slag, 6 cwt. gypsum, and 8 cwt. kainit. The effect of gypsum is always strongly marked, and throughout the whole of these experiments largely encouraged the growth of clovers. Here again kainit produced considerable effect, and confirmed former opinion as to the desirability of employing it extensively as a pasture manure. On every plot where it was used it caused a marked increase in the clover. Green vitriol has considerable reputation as a destroyer of moss in pasture, and the object of this experiment was to see its effect on the other herbage. When applied with gypsum and slag it was beneficial to the clover, and the cattle had not the slightest aversion to it. Where, however, it was applied to plots on which nitrate of soda was afterwards put, it had in each case an injurious effect; and in the report it is stated that evidently it "does not do to apply both nitrate and green vitriol in the same year."

Lime has, perhaps, not the same position it once had as a manure for pasture land, though it is difficult to see why. It is one of the best things to sweeten up a pasture, to discourage rank grass, and to improve the general quality of the herbage. M'Alpine pointed out some time ago that a sufficient supply of

lime is absolutely necessary for the proper growth and development of clover. Gypsum will, of course, supply the lime if it be applied, but it is not nearly so powerful in its effects; and in all cases where a rough pasture is to be dealt with, lime itself should be employed—at the rate of 3 to 5 tons per acre.

Salt is another pasture manure which is often neglected, and which might, with advantage, be used. Probably it is scarcely a manure in the ordinary sense of the term, as it supplies no important manurial ingredient, but it has a sweetening effect; it tends to kill moss, and discourages rough herbage; and above all, it engenders a healthy sanitary state in the pasture. Many diseases to which farm animals are subject may, to a great extent, be stopped by the regular use of salt. Take, for instance, "liver fluke" or "rot" in sheep, which is such a scourge on some land. The "fluke" is picked up by the sheep from the grass. One stage of its existence is passed in a small snail. Without the presence of that snail no "rot" can be contracted by the sheep. It having been conclusively proved that a weak solution of salt is fatal to the snail, the application of salt to pastures exterminates it. As confirmation of this, we find that in salt marshes and seaside pastures "rot" is practically unknown, and such cases as do occur are generally in sheep recently brought on to the lands, in which the disease has been far advanced. Where the disease is not far advanced, removal to such pastures has often resulted in their recovery. An autumn dressing of 12 to 14 cwt. per acre is invaluable.

CHAPTER VIII.

GENERAL CONCLUSIONS.

General effect of various manures, as shown by the experiments —Of nitrate—Phosphates—Potash alone and in mixtures—Manurial value of food stuffs—Unexhausted manurial value of purchased foods and manures.

In concluding this little work, we purpose making a general survey of the experiments at Rothamsted, pointing out the chief matters of importance.

We have already called attention to the fact that each crop has a special liking for some manurial ingredient. A fund of useful information has been accumulated as to the special effect of each class of manure both alone and in combination with others.

Nitrate of soda, for instance, has been studied, and its properties noted, so that much has been cleared up regarding its merits and demerits. There seems little doubt that it should not be used alone, except, perhaps, occasionally as a top dressing; but it is none the less valuable when used in conjunction with other fertilisers. It is its injudicious use only which has brought upon it its bad name. While being a food itself, it appears to act as a powerful appetiser, encouraging vigorous growth in the crop, and giving

it a greater capacity for making use of other feeding materials in the soil. It therefore enables the farmer to make the best use of the land, and to get a quicker and better return for his outlay in other manures. But given the appetite there must also be the wherewithal to satisfy it, hence the necessity for the use of other manures, unless the land be in specially good condition ; otherwise impoverishment of the soil results, and the crop suffers. One great reason for the rapid action of nitrate is its extreme solubility, and this constitutes an element of risk in its use. If full benefit is to be got from its application, it should be used when the plant is growing and so can make immediate use of it. As sulphate of ammonia is not so liable to be wasted, its time of application is not so important ; further, sulphate of ammonia may be with impunity mixed with superphosphate, whereas nitrate cannot without risk of loss of manurial matter and danger to those engaged in mixing.

The individuality of phosphate is not so strongly marked as that of nitrate, nor is exhaustion so likely to follow its use ; but if a manure is used alone, exhaustion of other manurial ingredients must follow to a greater or less extent, so that the continued application of one kind of manure alone is not to be recommended ; for as surely as the application of nitrate will exhaust the phosphate and potash, so surely will soluble phosphate or potash used *alone* tend to exhaust the other two. The exhaustion of potash is not a likely occurrence on heavy soils, but on light, free-draining soils it is by no means infrequent. Where this is the case it is impossible for

good crops to be raised, as the experiments have determined the importance of the part which potash plays.

At Rothamsted the whole of the experiments went to prove that scarcity of potash was accompanied by lack of constitution, that maturing was retarded, and the plant was less able to resist disease; and this is especially the case where nitrogenous manures have been used. We strongly advocate potash manures always being used the same year in which nitrate of soda and sulphate of ammonia are applied, for not only do they act as a check on the forcing action of these manures, but they improve the quality of the produce for feeding purposes and make it more palatable. We have seen cases where excellent results have followed the use of potash on soils which would be considered as well supplied, being decidedly heavy in character.

One of the most important questions upon which information has been gained at Rothamsted is that of the unexhausted residue of manures and feeding stuffs. Without entering here into the many questions raised by the Fertilisers and Feeding Stuffs Act,* or the great difficulties which must of necessity arise as matters are at present, especially in deciding what is due to

* The reader may do well to consult a little book, "Fertilisers and Feeding Stuffs: Their Properties and Uses," by a well-known authority, Dr Bernard Dyer. The same book contains the text of the Act, official forms and regulations for use in obtaining analyses, and legal notes on the Act by Mr A. J. David, of the Inner Temple (London: Crosby Lockwood and Son).

feeding stuffs and fertilisers and what to development of the natural fertility of the soil, we can point out some phases of the question upon which clear light has been thrown. The extensive draining experiments at Rothamsted have practically established the fact that the manurial matter escaping through the drains is, except in the lightest soils, limited to nitrate, and that the phosphates and potash have but small tendency to be washed out. In whatever form the nitrogen be applied to the soil it is being constantly changed into nitrate, and this change is most active during bare fallow. Nitrate of soda and sulphate of ammonia are readily washed out of the soil and leave no residue, but slower acting nitrogenous manures, such as horn dust, rape dust, and farmyard manure, though they do ultimately change into nitrate, and if not taken up by the crops find their way into the drains, still their residue remains in the soil for a long time, and the continued application of such manures results in a great accumulation of fertility. Messrs Lawes and Gilbert, writing on this subject, say that "when dung is applied continuously to the land, its accumulation to fertility becomes very large, and the removal by crops of the substance accumulated would extend over a long series of years." Both phosphates and potash manures are, as has been remarked, held somewhat tenaciously by most soils. Even soluble phosphate does not get into the drains, but becomes precipitated and mixes with the soil in an insoluble form. Doubtless some of it may find its way into the lower layers of the soil; but when we consider that only a relatively small proportion of

any dressing applied to the land is removed in the crop, and that this is specially so if the dressing be a heavy one, it becomes evident that the liberal manuring, with super for roots, must have the effect of largely increasing fertility and productive power. It may be said, of course, that the succeeding crops of the rotation will materially reduce this, which is indeed true, but it will not be exhausted by one or two crops.

In connection with the unexhausted residue of dung, Messrs Lawes and Gilbert have conducted most elaborate experiments to determine the relative value of the various foods as they affect the manure. This has been done by reckoning the amounts of the various ingredients stored up in the animals, and valuing the rest (which would be passed as liquid or solid excrement) at current manure prices. It is undoubted that the value thus assigned to the manurial matter derived from the foods is too high, as in practice there are so many opportunities of loss even in well-kept middens, while in badly kept ones the loss is difficult if not impossible to calculate. More than that, the richer the manure the greater the opportunity of loss, so that it is difficult to make the necessary allowance. Where, however, cattle are receiving cake on pasture, except in the case of milch cows and very young cattle, the practical manurial value of the food more nearly approaches the theoretical amount, as in this case the opportunities of loss are minimised. In any case, the table, as a guide to the comparative manurial values of food stuffs, is invaluable. A glance at this will show that for manurial value the cakes come first, then beans, tares,

lentils; closely following these are bran, middlings, and pollard; then clover hay; then the cereal grains and meadow hay; next straw; and, lastly, roots.

There is a difference in theoretical value between decorticated cotton cake, which heads the list, and yellow turnips, of about £5. A noticeable point is the much higher manurial value of decorticated than undecorticated cotton cake, the latter being only about two-thirds that of the former; so that when this is taken into consideration, as well as the risk of using undecorticated cake, the latter is really the dearer article. Cocoanut cake, much used now for dairy purposes, is below beans, lentils, and tares in manurial value. Of the cereals, oats has the highest, and maize the lowest value, if we except rice, which appears below maize. Pea haulm is the richest of the straws, but oat straw stands higher than wheat or barley.

Among roots, potatoes stand the highest, and yellow turnips the lowest. It is thus at once apparent that the initial value of manure produced by the various foods must vary between very wide limits, and thus afford considerable scope for the display of the ingenuity of the valuer; and when it comes to the consideration of manurial residue one or two years after use, the difficulties are enormously increased. Messrs Lawes and Gilbert have attacked this question also, and their suggestions are usually taken as the basis of assessments, subject to incidental conditions. Their figures are based on the probable increase a tenant would obtain by the use of a ton of cake or other food per annum to every 8 acres, and they have, after making allowance for loss, estimated the

unexhausted residue at a declining rate for succeeding years. From this they have arranged a scale of reduction, based on the original manurial value, as determined by them. Thus a half of the original manure value is taken off for food used during the previous year, and one-third each year up to the eighth. For instance, to quote an example given by them: If a ton of linseed cake (oil cake) were consumed every year for every 8 acres, and compensation were given for the last eight years, then the gross amounts due would be:—

Original Manure Value per Ton.	1st Year.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.
£ s. d.	£ s. d.	£ s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
3 18 6	1 19 3	1 6 2	17 6	11 8	7 9	5 2	3 5	2 4

Making a total of £5. 13s. 3d., or 14s. 2d. per acre. Thus upon the 8 acres there have been 8 tons consumed in eight years, and the total compensation is £5. 13s. 3d.

A good many of the scales of compensation adopted are not dependent upon the manurial value of the food, but upon the market value. This is obviously not so perfectly fair, but as many of the market values vary as do the manure values, the difference is probably not very great. The scale adopted by the Lincolnshire land valuers, as given by F. Clifford in the Royal Agricultural Society's *Journal*, No. 20, is: One-third the cost of cake consumed during last year of tenancy, and one-sixth cost of cake consumed the year previous. In the case of malt, and other purchased feeding stuffs of similar manurial value, only

one-sixth the value during the last year of tenancy, and one-twelfth the year previous, is allowed.

By this, if we reckon that a ton of linseed cake, value £6. 10s., is consumed per 8 acres every year, we shall have about 8s. per acre as compensation. This is about the same result as in the Lawes and Gilbert example, if the compensation is reckoned as for two years instead of eight. Though compensation would not be given in practice for more than two years, it is obvious that the amount of cake given for many years previous should be taken into account, otherwise the expenditure might be limited to the last two years of tenancy. In Lawes and Gilbert's tables a high value is assigned to the manure from home-grown corn, oats having considerably more than one-third the value of linseed cake. No account, however, is taken as yet of home-grown corn consumed on the farm, though it is obvious that the value of the manure must be vastly increased by its use.

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